# THE EFFECT OF INITIAL DEFLECTION ON THE STRESS DISTRIBUTION IN A PANEL OF SHIP'S PLATING UNDER TENSILE LOAD

ARTHUR JACOB HASKELL
AND
ROBERT EDWARD WURLITZER

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Page 18
Figure XIII, Page 22
Figure XXXIII, Page 44
Figure XXXIV, Page 45
Figure XXXV, Page 46
Figure XXXVI, Page 47
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Figure XXXIX, Page 50
Figure XL, Page 51
Page 55
Page 56
Page 60

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Lieutenant (jg), USN

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by

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SUBMITTED IN PARTIAL FULFILLMENT
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NAVAL ENGINEER

at the

MASSACHUSETTS INSTITUTE OF
TECHNOLOGY

May 1953

# ABSTRACT

## THE EFFECT OF INITIAL DEFLECTION ON THE STRESS DISTRIBUTION IN A PANEL OF SHIP'S PLATING UNDER TENSILE LOAD

by

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Junior Grade, U. S. Navy

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Submitted to the Department of Naval Architecture and Marine Engineering on 25 May 1953 in partial fulfillment of the requirements for the degree of Naval Engineer.

The object of this work was to commence an investigation whose ultimate aim would be to quantitatively relate the maximum stress in a ship's panel under uniform tension to the amount of deflection initially present in that panel. The results of such an investigation may provide information related to ship failure and may further provide plating deflection criteria for shipbuilders.

The method of testing was as follows:

1. An 18" x 6" x 1/8" stiffened panel, representative of ship's plating, was constructed and welded to pulling members adapted to fit a 300,000 pound tensile testing machine. One of the two panels tested was plane, the other had deflection roughly equal in magnitude to the plate thickness.
2. SR-4 rectangular rosette strain gages were utilized to obtain the strain pattern on both sides of the plate.
3. The samples were then tested, strain readings taken at loads from 20,000 to 140,000 pounds at 20,000 pound increments.

Calculations were performed to obtain the pattern of principal strains existing on the plates. The test results were then modified to represent a condition of uniform strain along the edge.

The results showed that the points of maximum deflection of the distorted plate supported very little of the load, while very high

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stresses existed near the stiffeners. This did not appear to be the case for the plane panel. It was considered that the results of the two tests conducted did not yield sufficient information to quantitatively relate stress distribution and initial deflection.

Recommendations for future work included the following suggestions:

1. Construction and testing of more samples of varying amounts of deflection and aspect ratio.
2. Investigation of the possibility of modifying the design of the pulling members to obtain a more uniform load condition at the edge.
3. Integration of stress curves at edge and center of plate to verify test data.
4. Eventually preparation of plots of maximum deflection to plate thickness ratio versus ratio of maximum stress to uniform stress along plate edge.

Thesis Supervisor: John Harvey Evans
Title: Associate Professor of Naval Architecture

Cambridge
Massachusetts
May 25, 1953

Secretary of the Faculty
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

Dear Sir:

In accordance with the requirements for the Degree of Naval Engineer, we submit herewith a thesis entitled, "The Effect of Initial Deflection on the Stress Distribution in a Panel of Ship's Plating under Tensile Load".

Respectfully yours,

# ACKNOWLEDGMENT

The authors wish to acknowledge their indebtedness to Professor J. H. Evans for his helpful advice and criticism and to those members of the Mechanical Engineering, and Naval Architecture and Marine Engineering Departments without whose cooperation this thesis could not have been written.

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# I INTRODUCTION

The significant number of failures of merchant and naval vessel structures in recent years have led to many investigations into the causes of these failures. On page 10 of reference (1) it was concluded that, "The fractures in welded ships were caused by notches and by steel which was notch sensitive at operating temperatures. When an adverse combination of these occurs the ship may be unable to resist the bending moments of normal service". Notches, whose presence is considered necessary to initiate failure may be caused in several ways. Notches resulting from fabrication or inadvertently built into the design (as at hatch corners) have been previously considered. High stress concentrations in a localized area of ship's plating may cause a local fracture which may form the notch needed to initiate failure.

A theory advanced to the authors by Professor J. H. Evans, of Massachusetts Institute of Technology relates the variation in stress concentration to the amount of initial bulge in the panel between stiffeners of a section of ship plating. Suppose, for example, initial bulge exists in a section of a transversely framed ship's hull. In addition let us assume that the section is in tension (as a section of the bottom shell would be with the ship sagging). The section of the plating containing the bulge will be unable to assume its apportioned share of the load until the deflection is removed. The section of the plating adjacent to the longitudinal members will therefore receive and maintain a disproportionately high part of the load. It is conceivable that the high stresses developed could cause cracking, and subsequent

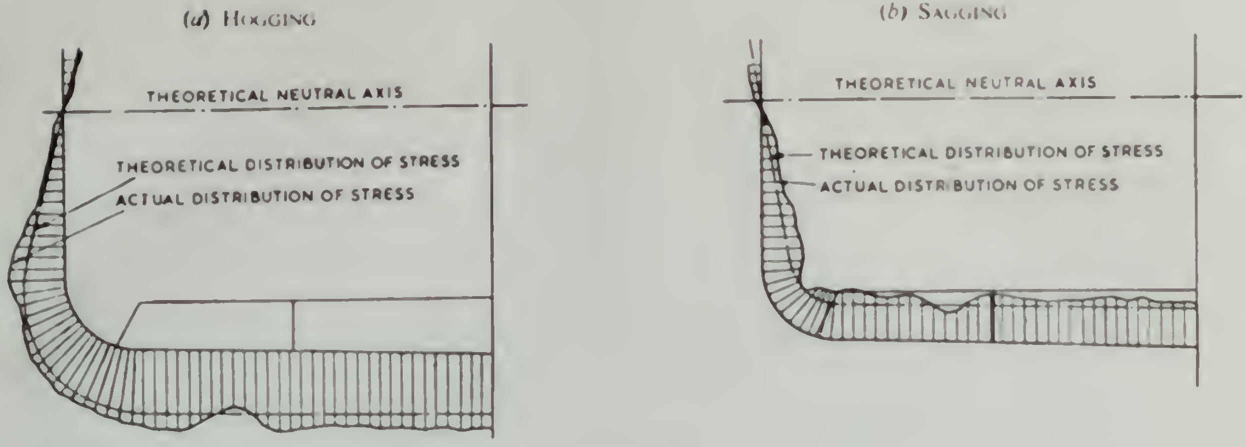
failure, in this region before the distorted section began to carry its portion of the load.

Several investigations have included observations which tend to substantiate the foregoing ideas. The authors' research has not disclosed any work which relates initial deformation to stress distribution. The Admiralty Ship Welding Committee reports of the full scale tests on the *Neverita*, *Newcombia*, *Ocean Vulcan*, and *Clan Alpine* are reviewed by Turnbull in reference (2). The findings of interest to this report are well summarized in Figure I,(reproduced from reference 2). The stresses in the way of the longitudinal stiffeners of the welded ship for both hogging and sagging are much greater than the stresses clear of that stiffening. Note that this is not as true for the case of the riveted ship. The report states: "The unfairness of the bottom plating between frames clear of the longitudinal stiffening in the welded *Ocean Vulcan* was in general about double that of the riveted sister ship". Thus the difference in stress from the center of the panel to the stiffeners would be expected to be less in the riveted ship than in the case of the welded ship.

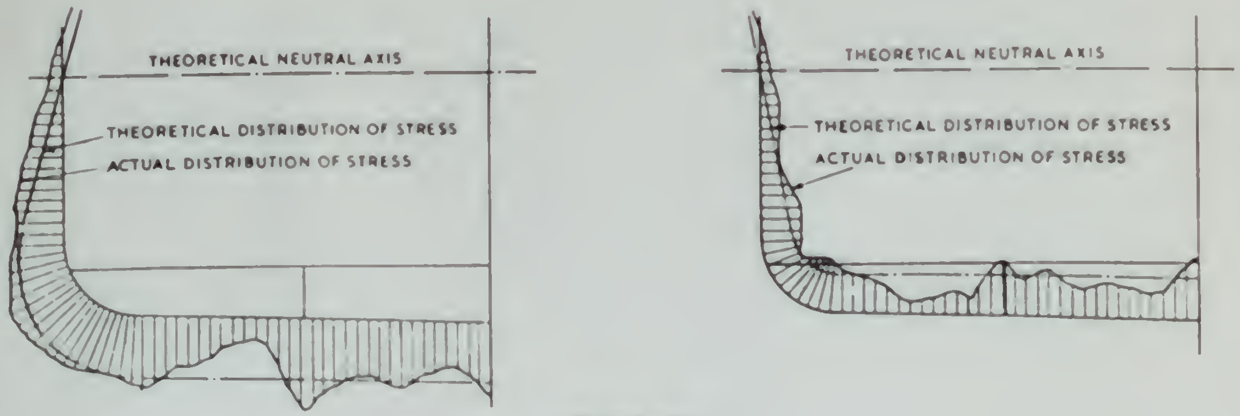
These observations indicate that it is probably true that initial distortion has an effect on stress concentration. That this effect is great enough to initiate ship failure has not been determined. The idea motivating the authors was to commence an investigation whose ultimate aim would be to quantitatively relate the maximum stress in a ship's plate under uniform tension to the amount of bulge initially present in that plate. It is felt that the results of this investigation

FIGURE I

Distribution of longitudinal stresses for bottom shell plating near amidships for merchant vessels.


(a) Hogging
(b) Sagging
THEORETICAL NEUTRAL AXIS
THEORETICAL DISTRIBUTION OF STRESS
ACTUAL DISTRIBUTION OF STRESS
THEORETICAL NEUTRAL AXIS
THEORETICAL DISTRIBUTION OF STRESS
ACTUAL DISTRIBUTION OF STRESS

RIVETED SHIP


THEORETICAL NEUTRAL AXIS
THEORETICAL DISTRIBUTION OF STRESS
ACTUAL DISTRIBUTION OF STRESS
THEORETICAL NEUTRAL AXIS
THEORETICAL DISTRIBUTION OF STRESS
ACTUAL DISTRIBUTION OF STRESS

WELDED SHIP

may provide information related to ship failure and may further provide plating deflection criteria for shipbuilders.

# II PROCEDURE

## 2.1 Design of Test Section

The design and construction of the samples together with the selection of the testing machine were the first problems faced. It was considered desirable to test a sample representative of ship's stiffened plating. The design of the test section was governed by several practical considerations. The thinnest plate that it was considered practical to weld by the conventional continuous process was 1/8 inch thick. The longitudinal stiffeners were selected to provide adequate stiffness with the minimum cross-sectional area. The width of the sample, 24 inches, was then determined by the 300,000 pound capacity of the tensile testing machine available. The fracture load of the machine was limited to 225,000 pounds. This corresponds to an average stress of 60,000 p.s.i. for the sample as designed. Longitudinal stiffeners were then placed 18 inches apart. The distance between transverse stiffeners was set at 6 inches to give an aspect ratio of 3:1 inside the stiffeners, considered to be a representative value.

The specimen constructed for testing is illustrated in Figures II and III. It consists of the test panel to which are welded the pulling members. The 12" x 24" test panel is constructed of 1/8 inch medium tensile steel, minimum tensile strength 60,000 p.s.i., maximum carbon content 0.31%, Federal Specification M-48-S-5, Grade M. The transverse angles are 1½" x 2½" x 3/16" and the intercostal longitudinal angles are 1-3/8" x 7/8" x 3/16". The angle material is Federal

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# FIGURE II

TEST SECTION AND PULLING MEMBERS

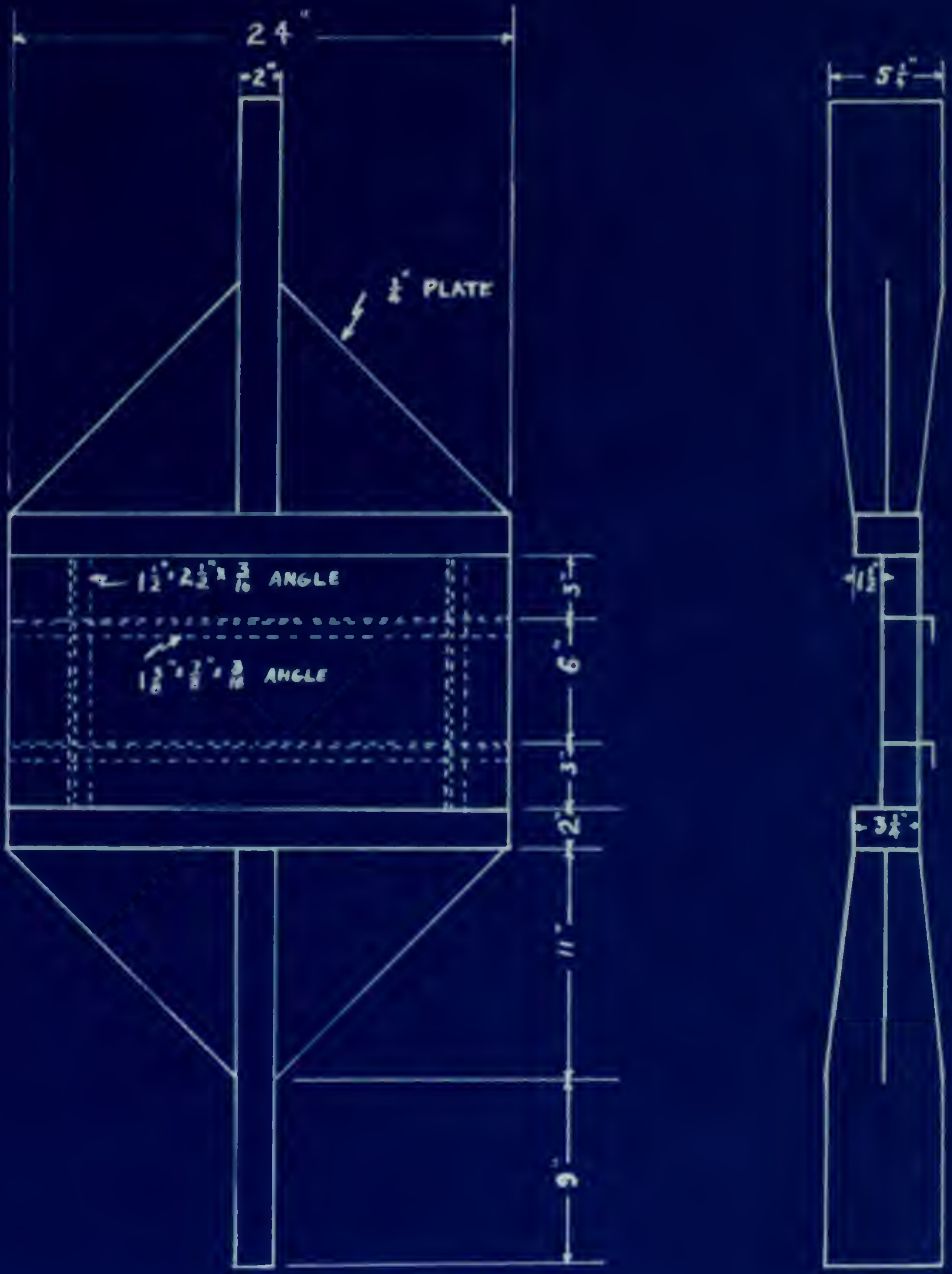
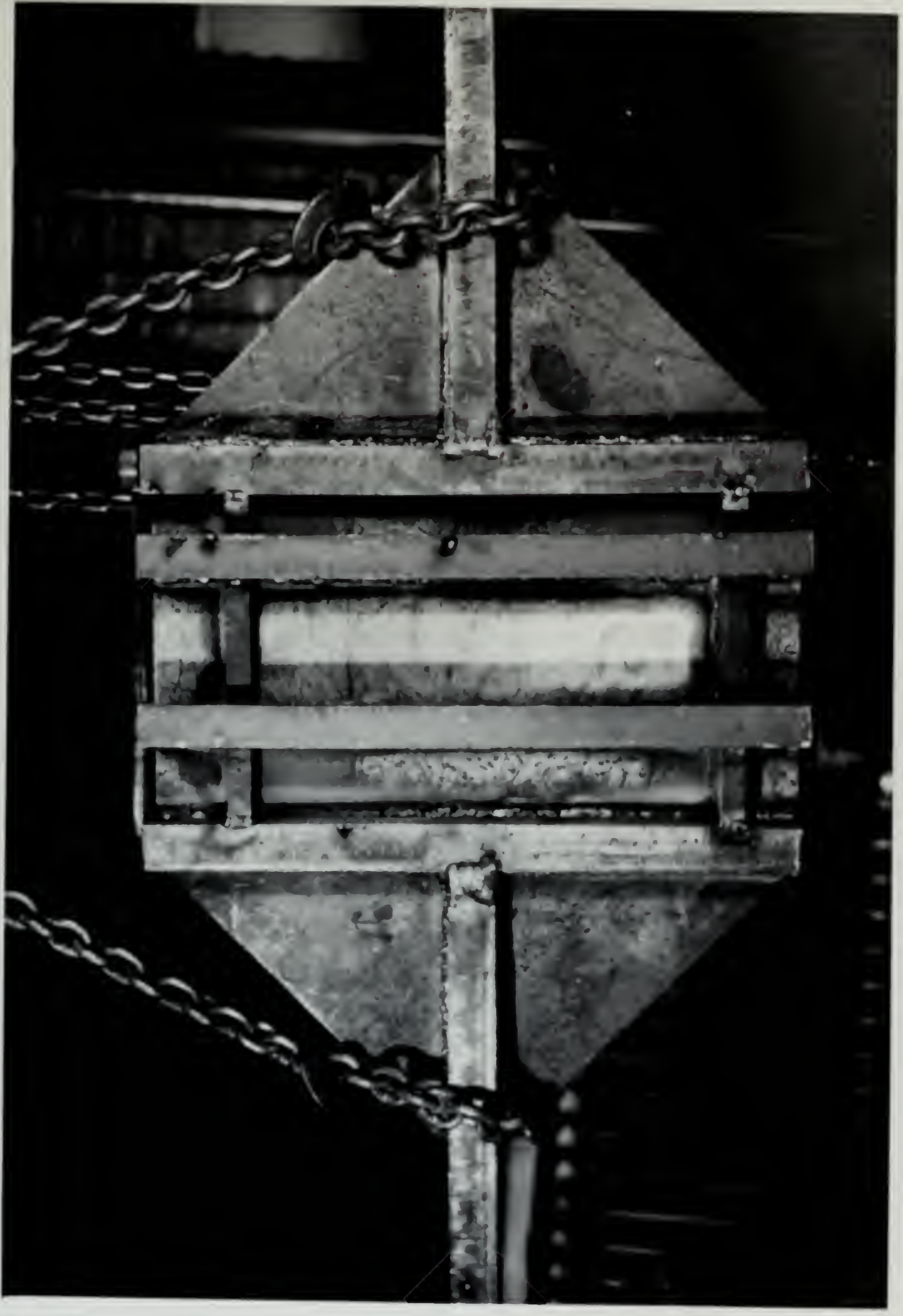


FIGURE III

Test Section and Pulling Members



Specification M-46-S-1, Grade M, Type A, hot-rolled carbon steel, minimum tensile strength 60,000 p.s.i.

## 2.2 Design of the Pulling Members

Adapting the specimen to be fitted into the jaws of the testing machine and at the same time providing a condition approaching uniform tension along the length of the test section were the controlling factors in the design of the pulling members. The design of these units included the following features:

2.2.1 A 24 inch long, 2 inch thick steel plate is welded to the specimen. This relatively thick plate was selected to help transform the essentially point load of the machine to a uniform tensile load at the sample.

2.2.2 1/4 inch gusset plates were fitted to assist in obtaining the uniform tension desired.

2.2.3 The 5½" x 2" dimensions at the pulling member head gave adequate cross-sectional area to transmit loads up to 300,000 pound limit of the machine. This area was reduced as the vertical member approached the sample. This safely reduced the weight of the pulling members, since the lost area was supplied by the gusset plates.

2.2.4 The pulling members were constructed of the same material as the 1/8 inch plate.

## 2.3 Joining Test Section and Pulling Members

The design provided for a welded joint between test section and pulling members. The connection was made so that the neutral axis of

the pulling member coincided with the neutral axis of the plate-stiffener combination. This was done to eliminate bending as much as was possible.

## 2.4 Fabrication

The construction of the samples was undertaken by the Shipfitter Shop of the Boston Naval Shipyard, Boston, Massachusetts. The fabrication process used for construction of the undistorted sample was as follows. The sample was dogged down and the weld deposited around the inside of the stiffeners using a block and backstep sequence. The same process was repeated around the outside of the stiffeners. It was originally decided to attempt to introduce distortion into the samples by varying the welding sequence. It was found that the unsupported length between transverse stiffeners was not great enough to allow distortion of the depth desired. It was finally decided to heat a sample with an oxy-acetylene torch. By heating and air cooling the center section of the specimen it was possible to introduce the desired amount of distortion in the plating. It is estimated that the sample did not exceed a temperature of 1700° F during the process, so that it is considered that the metallurgical structure of the steel did not change from its previous condition.

## 2.5 Contour Measuring Device

In order to measure the distortion of the samples a contour measuring device was constructed. (See Figure IV). It consists of four brass legs whose vertical height may be adjusted by means of threaded

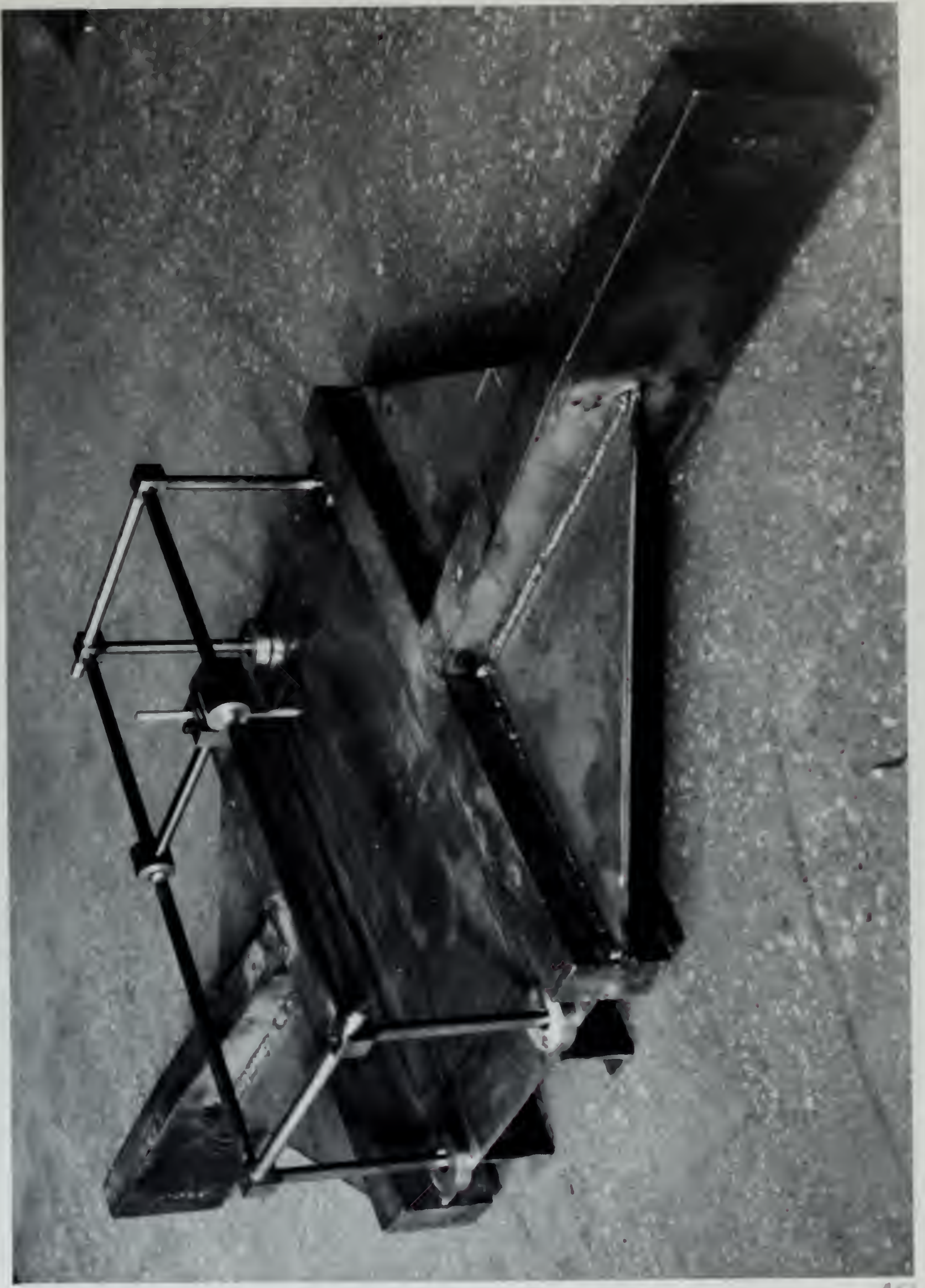


FIGURE IV

Contour Measuring Device

base pieces. On the cylindrical supports between the legs rides a horizontal carriage whose position can be varied along the length of these supports. On the carriage is a holder for a dial-gage which can be moved back and forth on the carriage. The measuring process consists of first adjusting the plane of the measuring device parallel to the theoretical plane including the four points of intersection of the stiffeners on the unstiffened side (henceforth referred to as the reference plane). This can be done as long as the plane has not twisted. The amount of distortion in the panel between stiffeners is than measured. A contour map can then be prepared with the data obtained.

### 2.6 Preparation of Panel 1 and Equipment for Test

It was decided to use a relatively plane sample for the first test. The panel selected, henceforth referred to as Panel 1, was determined to be within ± 0.003 inches of the reference plane.

The strain gages selected to measure the plate strains were Baldwin SR-4 Type AR-1. These are rectangular ($45^\circ$) rosettes, whose component gage lengths are 13/16 inch. Rosettes were selected because it was desired to determine the angle between the axis of principal strain and the axis of pull. The location of the rosettes is depicted in Figures V and VI. The gage locations on the stiffened side are drawn as if the panel were transparent and an observer were looking through from the unstiffened side. The gage locations were selected to attempt to obtain an over-all picture of the strain distribution. Gages on the edge were located to determine if uniform tension along the edge was obtained and if symmetry about the center of the panel was realizable. Particular interest in the nature of the strains near the stiffeners is reflected by

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FIGURE V

LOCATION OF STRAIN GAGES ON UNSTIFFENED SIDE OF PANEL ONE

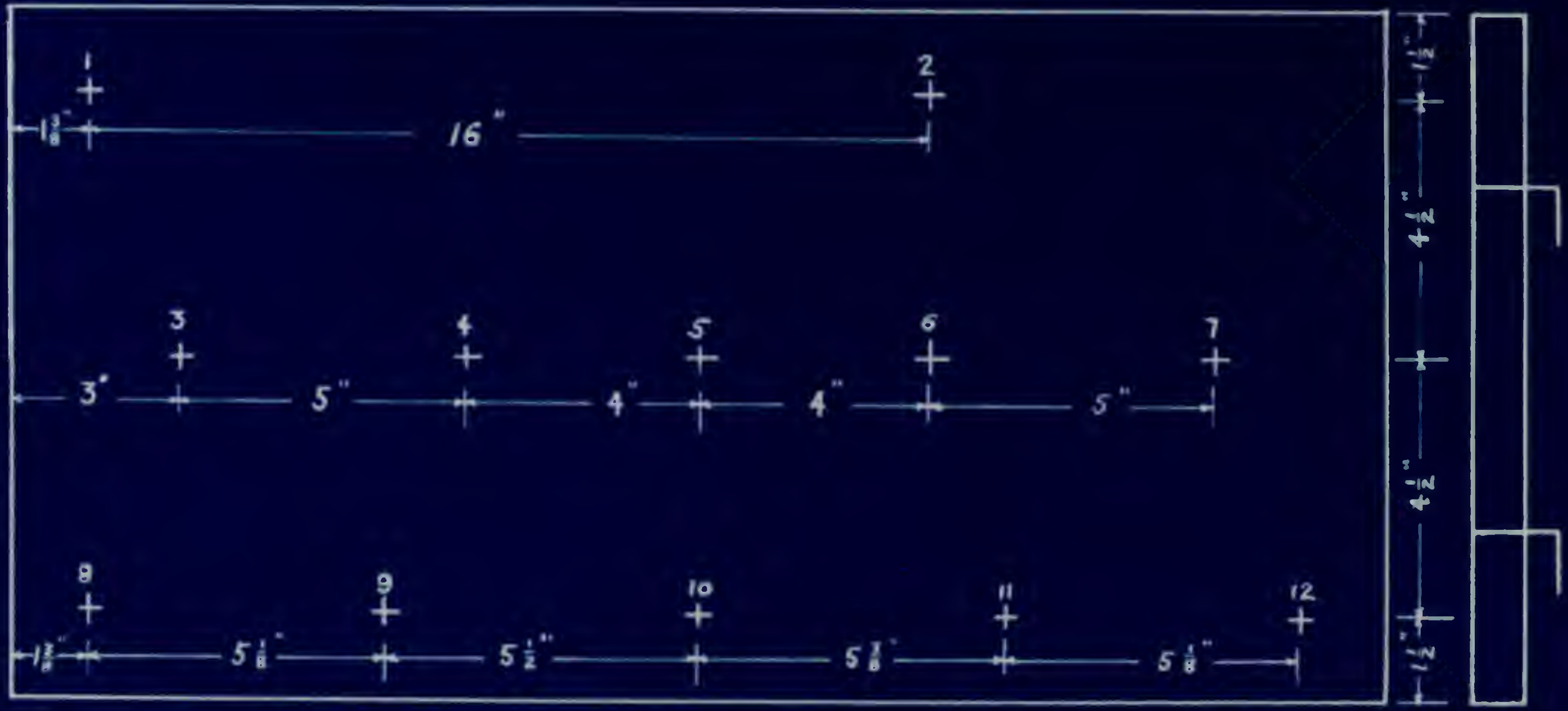

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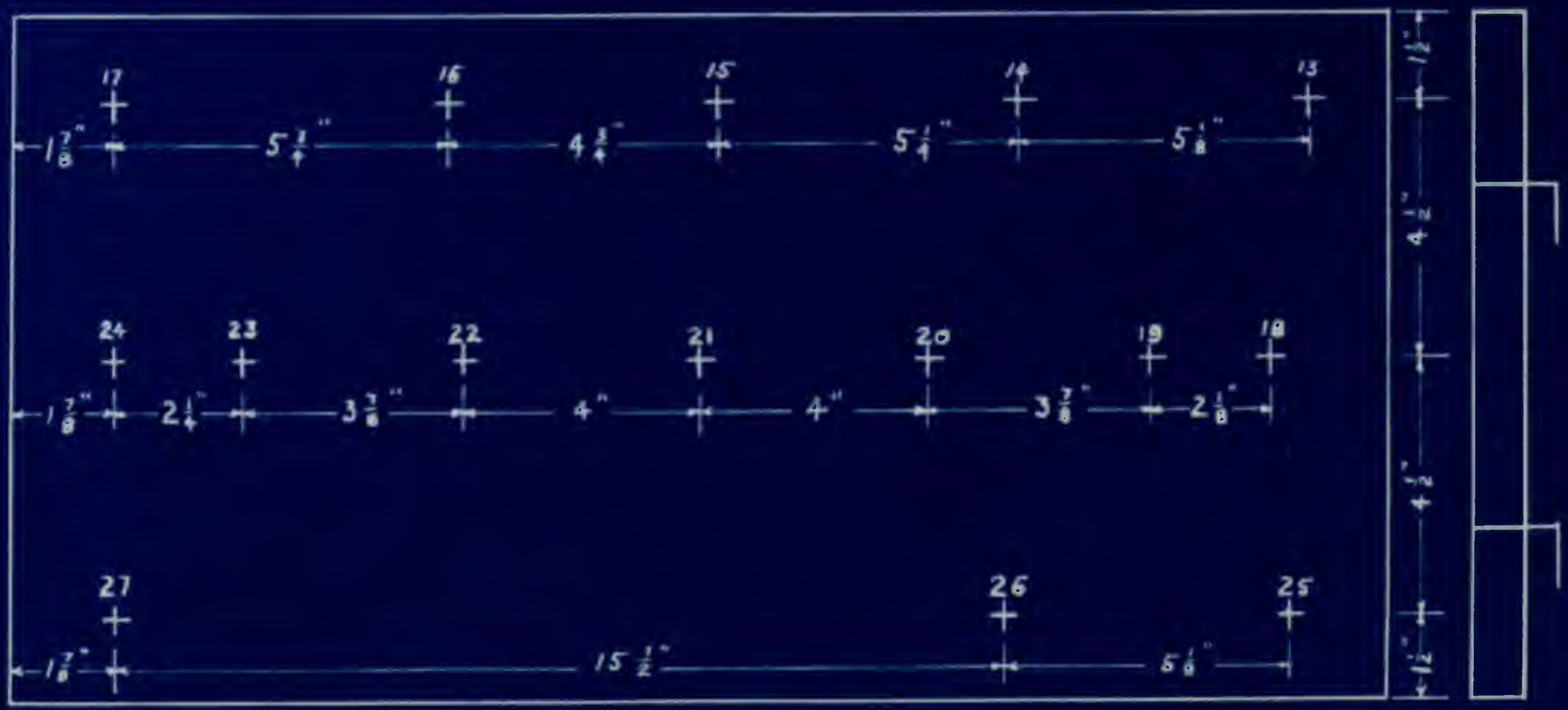
FIGURE VI

LOCATION OF STRAIN GAGES ON STIFFENED SIDE OF PANEL ONE LOOKING THROUGH PANEL FROM THE UNSTIFFENED SIDE.



the locations of gages 3, 7, 24, 23, 19, and 18.

The question of obtaining rapid, reliable, readings on the strain indicator unit (a Baldwin SR-4 Indicator Box, Type K) was the next problem faced. The 27 rosettes necessitated 81 readings. The only switching unit available capable of handling that number of gages was a rotary-switch unit. Variable contact resistance was found to exist during preliminary testing. The magnitude of this variable resistance introduced errors too large to be tolerated (in some cases resistance changes measured several hundred micro-inches per inch). A switching unit (Figure VII) was constructed consisting of 41 double-throw, single-pole, copper knife switches of 25 ampere rating. These switches reproduced readings within 10 micro-inches per inch during preliminary tests.

## 2.7 Test of Panel 1

The machine upon which this test and the test of Panel 2 was conducted was a Southwark-Emery hydraulic type testing machine, capacity 300,000 pounds, M. I. T. Serial 105. The control panel for this machine is shown in Figure VIII. The sample mounted in the machine is pictured in Figure IX.

The following procedure was employed for the test of Panel 1.

2.7.1 The sample was cycled by raising the load to 5000 pounds and returning to zero load until consecutive zero readings were repeated.

2.7.2 The load was raised to 20,000 pounds and the readings on all gages recorded. This procedure took about 25 minutes.

FIGURE VII

Switching Unit

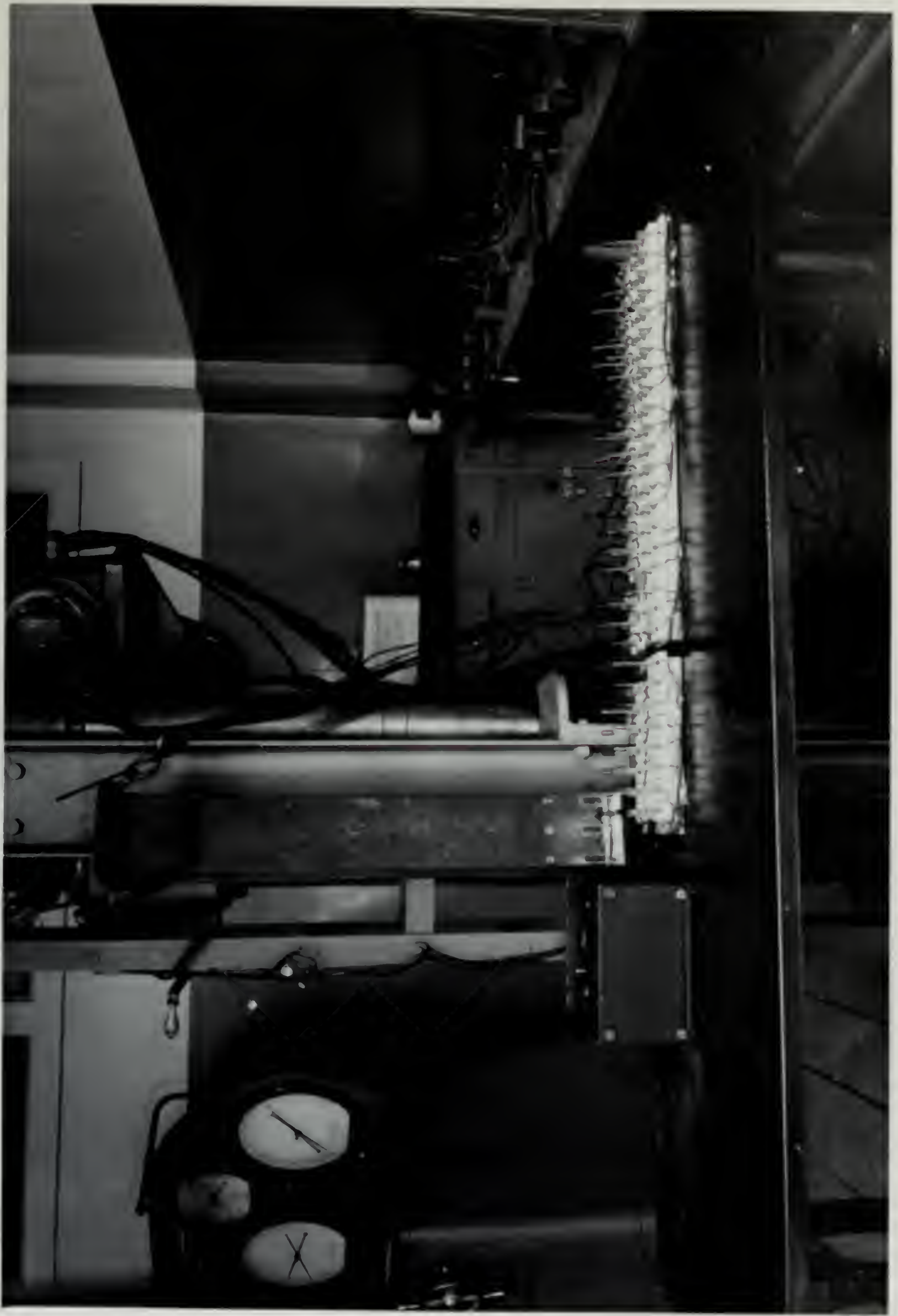
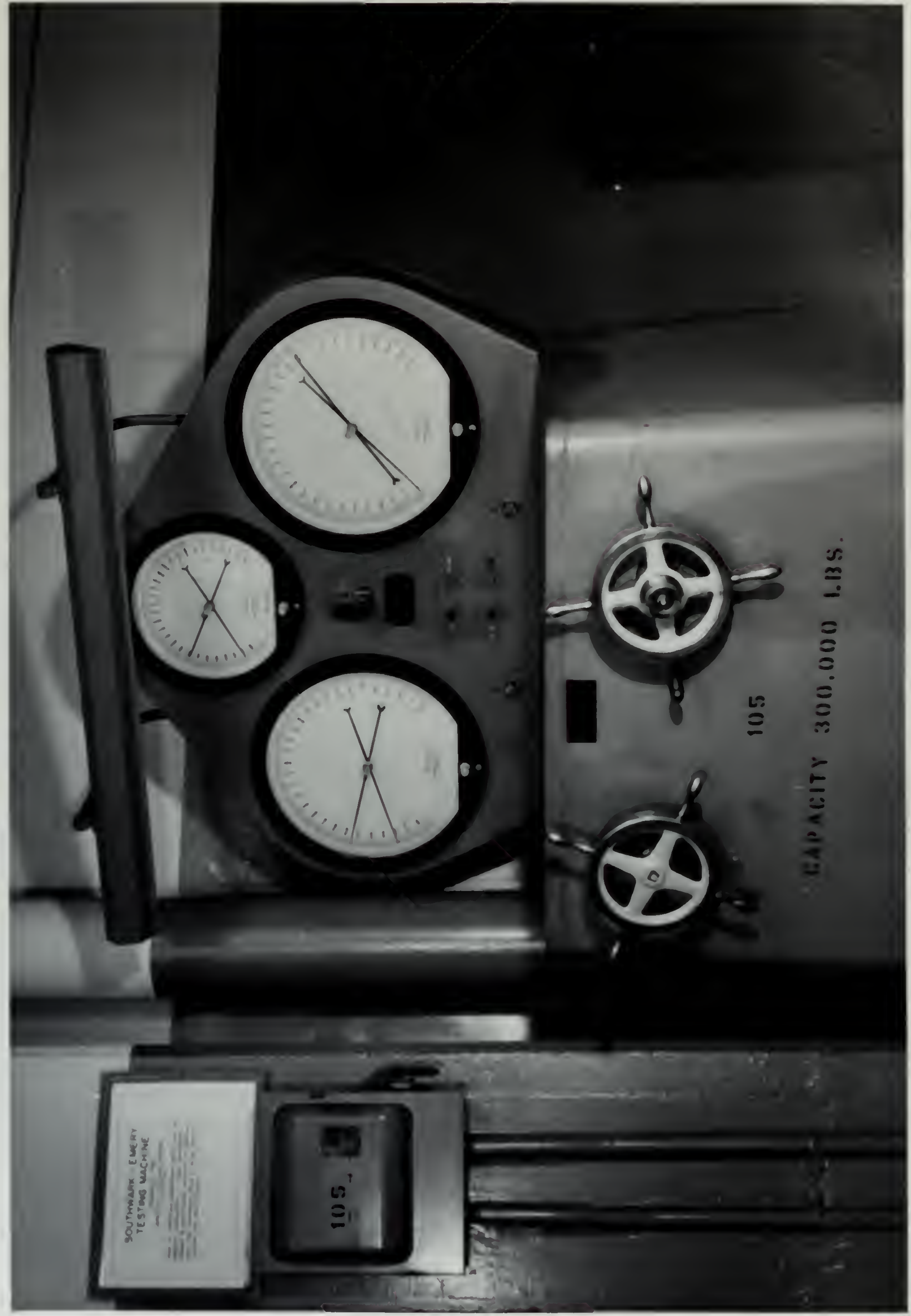


FIGURE VIII

Testing Machine Control Panel



2.7.3 Readings were repeated at loads of 40,000, 60,000, 80,000, 100,000, 120,000, and 140,000 pounds.

2.7.4 The load was slowly increased until the sample fractured. The following visual observations were noted during this test:

2.7.5 At 155,000 pounds load the sample began to creep noticeably and it was no longer possible to take a set of strain gage readings.

2.7.6 As the load increased the horizontal portion of the pulling members bowed noticeably, the middle section of the pulling member experiencing greater deflection than the ends.

2.7.7 The transverse stiffeners bowed considerably at 196,000 pounds. The bowing was such that the edge of the stiffener welded to the plate was concave.

2.7.8 The welded edges of the longitudinal stiffeners were also bowed concavely. The free edges of the plate bowed in the opposite direction.

2.7.9 At 207,000 pounds the sample failed, the failure apparently starting at a notch located on the free edge of the plate.

## 2.8 Preparation and Test of Panel 2.

Panel 2 was a sample distorted by the heating process previously described. Figure X represents a contour map of the sample. Figure XI is a transverse section through the center of Panel 2.

The strain gage locations on Panel 2 were altered as a result of the experience gained in conducting the first test. The gage configuration is shown in Figures XII and XIII. The important changes are:

2.8.1 More gages were placed on both sides of the test section to obtain a better picture of the strain gradient.

2.8.2 Gages were placed on both sides of one edge of the sample to get a better picture of the edge loading.

2.8.3 Six SR-4, Type A-1 uniaxial gages were placed on the longitudinal stiffeners.

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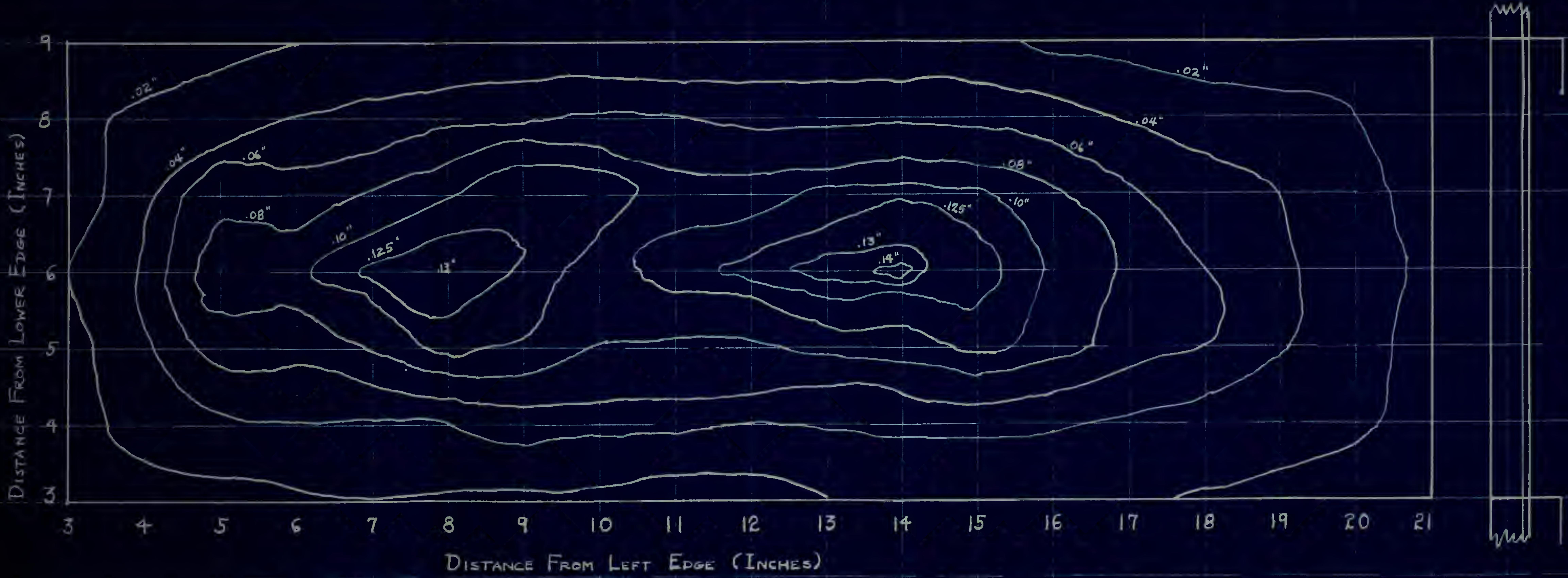
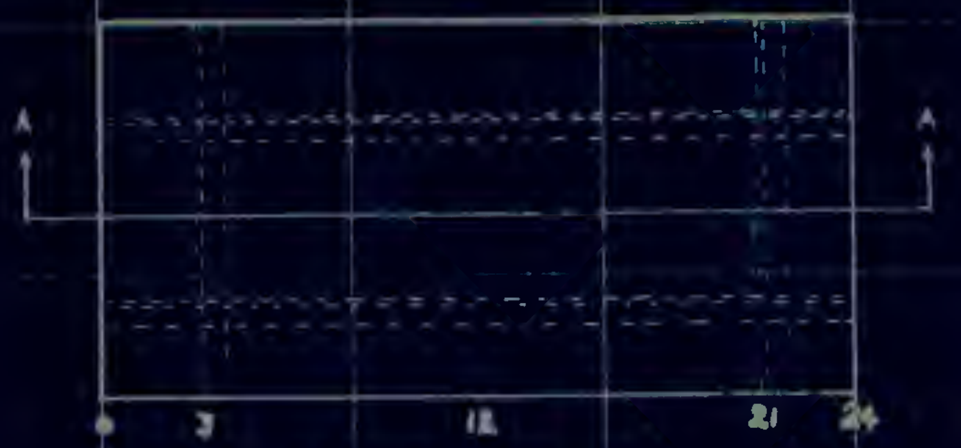
FIGURE X

CONTOUR MAP OF PANEL #2
SHOWING DEVIATION FROM PLANE PLATE
(CONCAVE ON UNSTIFFENED SIDE)

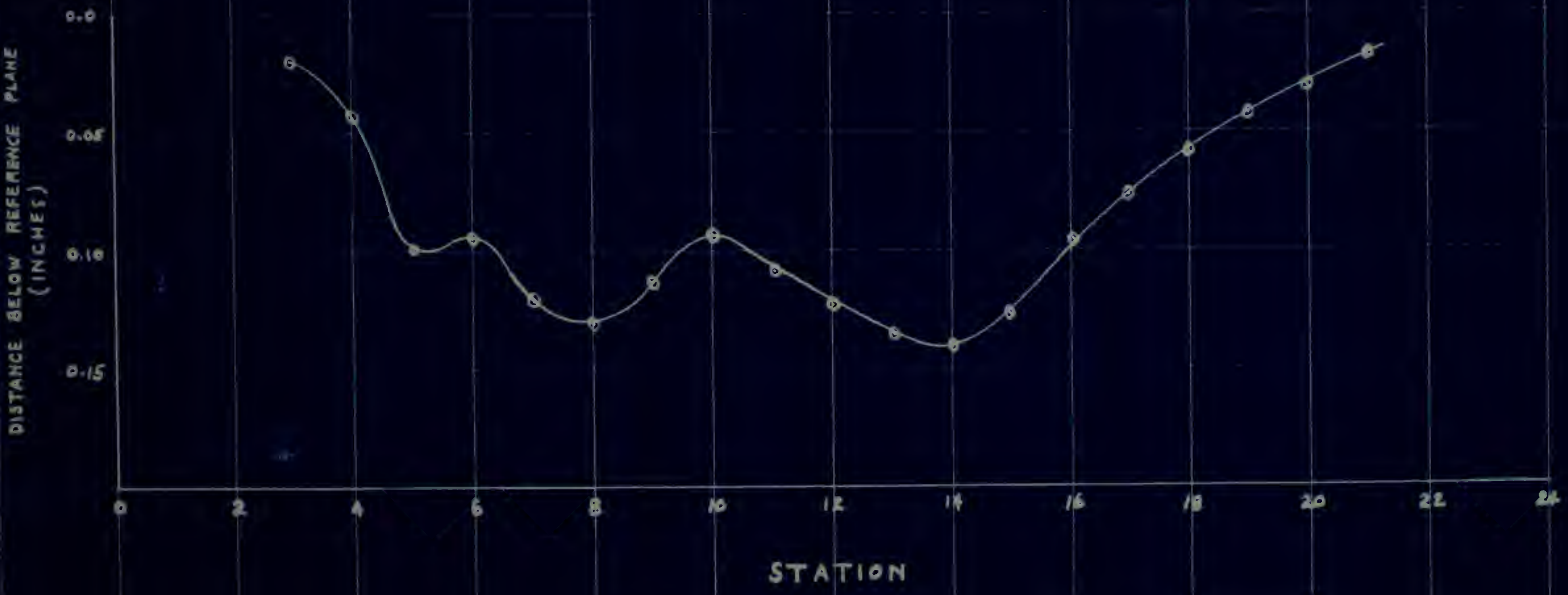


## FIGURE XI

TRANSVERSE SECTION AA FOR PANEL 2
SHOWING DISTORTION OF PLATING.



SOME STATIONS OF TEST SECTION



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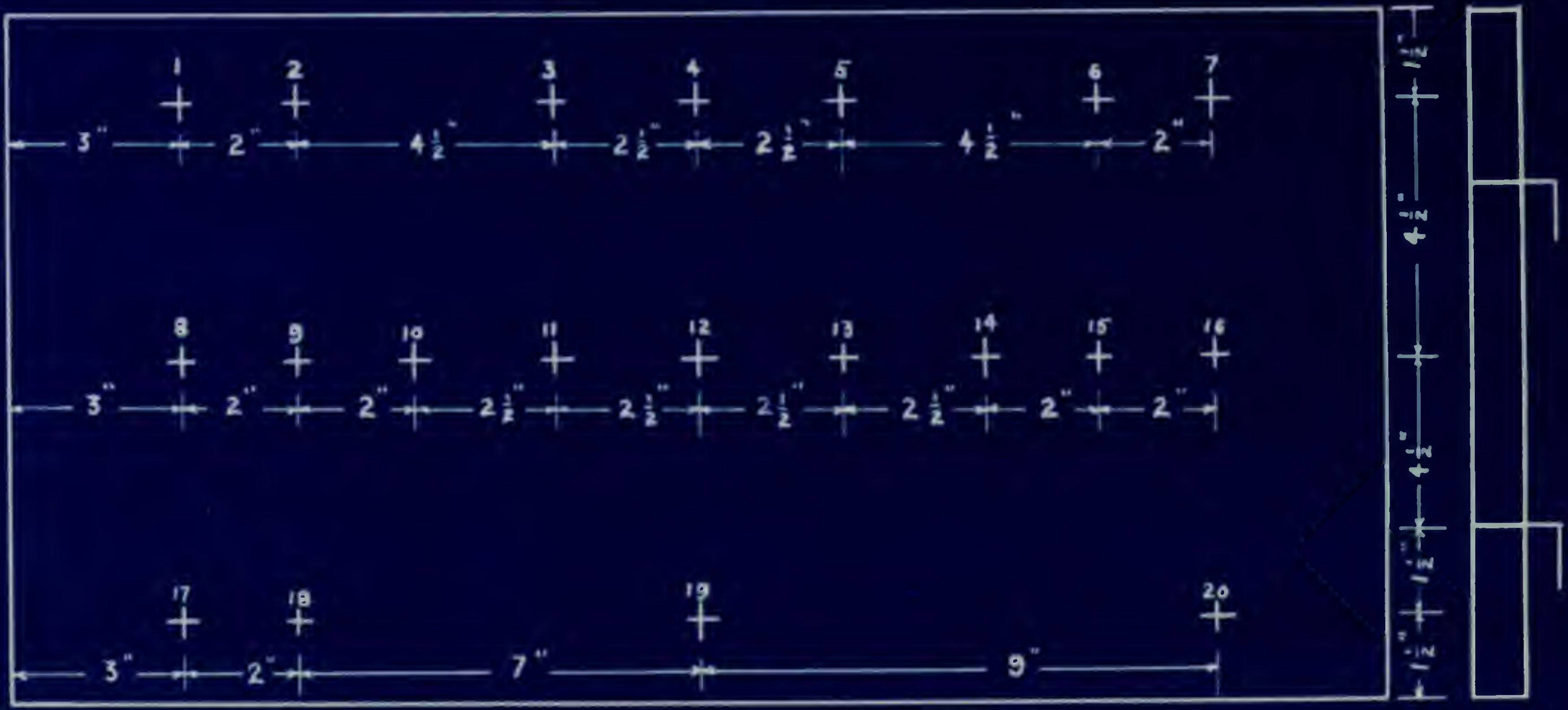
[illegible]

# FIGURE XII

LOCATION OF STRAIN GAGES ON UNSTIFFENED SIDE OF PANEL TWO.



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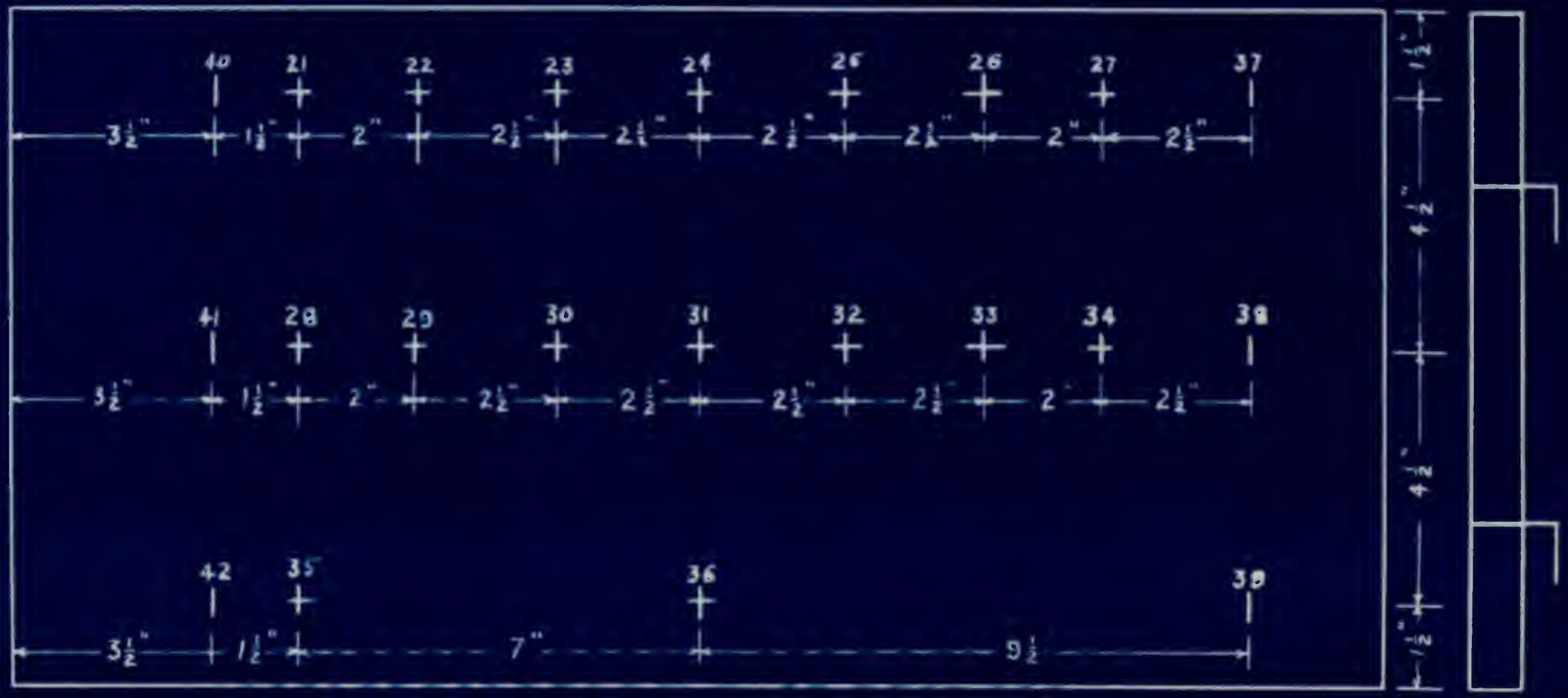
# FIGURE XIII

LOCATION OF STRAIN GAGES ON STIFFENED SIDE OF PANEL TWO LOOKING THROUGH PANEL FROM THE UNSTIFFENED SIDE. GAGES 37-42 WERE LOCATED ON THE FLANGE OF THE LONGITUDINAL STIFFENERS.



The procedure identically followed the procedure of paragraph 2.7. The following visual observations were made:

2.8.4 The specimen started to creep at about 155,000 pounds.

2.8.5 The distortion of the horizontal portion of the pulling members and transverse stiffeners was not as great as for Panel 1.

2.8.6 Failure occurred at 209,000 pounds along the weld between pulling member and plate.

## 2.9 Stress-Strain Curve

A stress-strain curve (Figure XIV) for the material of the plate was prepared utilizing a standard tensile specimen for 1/8 inch steel plate, as found as Figure 2 on page 376 of reference (3).

## 2.10 Method of Analysis

The method of analysis for both samples was identical. The object of the procedure used was to obtain a stress picture at the center of the section with a uniform tensile load on the edge. The following steps were taken:

2.10.1 Rosette calculations for magnitude and direction of principal strains were obtained from the test data (see Appendix, Tables I and II). (A strain of 9460 micro-inches per inch should be added to all readings proceeded by "A"). The sequence calculations appear in Tables III through XVI of the Appendix. Results of the calculations showing magnitude and direction of principal strains are included as Tables XVII and XVIII of the Appendix.

2.10.2 A plot of principal strains versus stations was then made.

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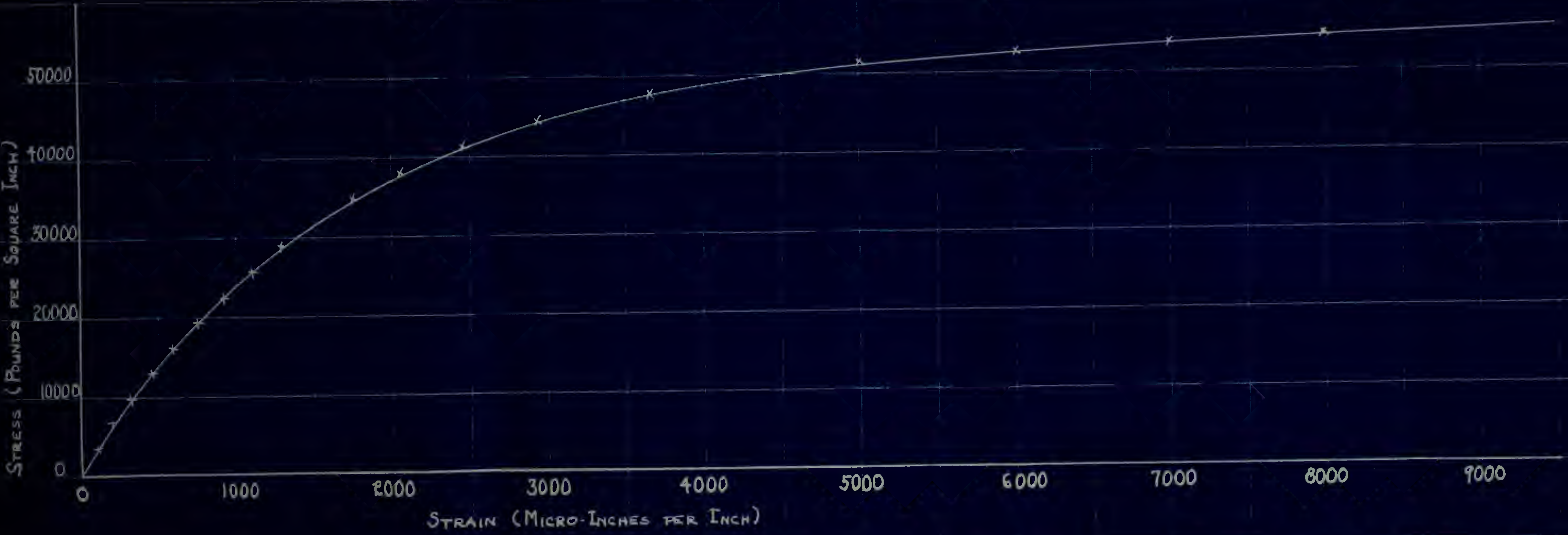
FIGURE XIV

STRESS-STRAIN CURVE FOR STEEL OF TEST PANEL

MEDIUM TENSILE STEEL MAX CARBON CONTENT 0.31%



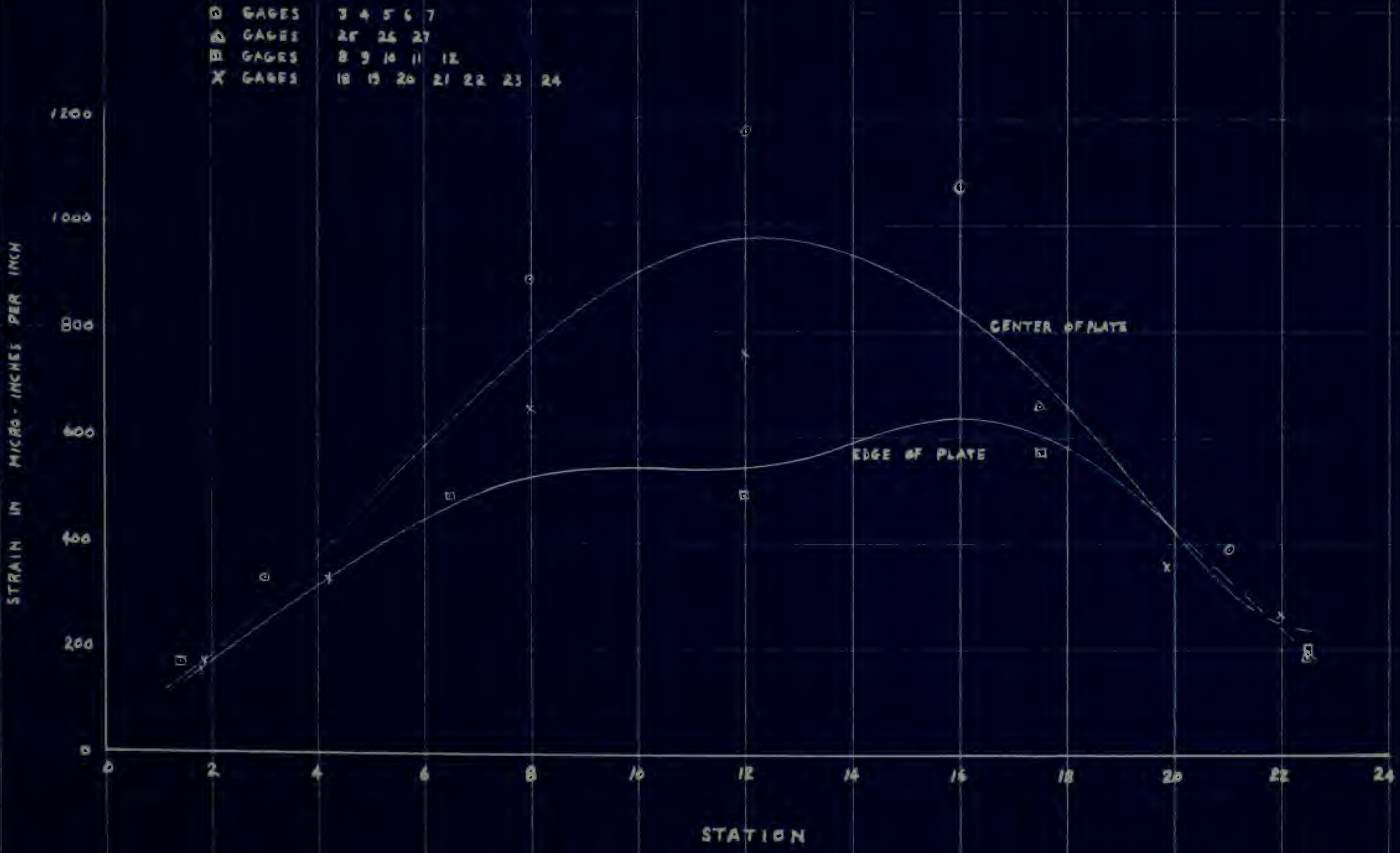
The number of a station is defined as the distance in inches from the left edge of the panel with the flanges of the transverse stiffeners pointing downward as an observer looks at and through the unstiffened side. A curve was then drawn using the arithmetic mean of strain readings on opposite sides of the panel. Figures XV and XVI represent typical curves for loads of 40,000 and 120,000 pounds on Panel 1. Figures XVII and XVIII are the curves for the same loads on Panel 2.

2.10.3 Next the cross-curves (Figures XIX - XXXII) for seven stations on each plate were prepared. The points for a particular station were obtained by plotting mean strain at that station versus the load at which that strain occurred. The strains used were the values read from the plots of paragraph 2.10.2. Two curves for each station were then drawn; one depicting edge strain versus load, the other center of plate strain versus load. These curves were faired in to minimize errors made in the construction of the curves of paragraph 2.10.2.

2.10.4 It was now possible to construct the stress and strain pattern at the center of the plate for a uniform tensile loading on the edge. Uniform strains of 500, 1000, 1500, and 2000 micro-inches per inch were selected. For each station the corresponding center of plate strain was plotted against station number. The resulting curve represented center of plate strain for uniform strain at the edge. The stress pattern was then plotted from the stress-strain relationship of Figure XIV. The uniform tension curves are included as Figures XXXIII - XXXVI for Panel 1 and Figures XXXVII - XL for Panel 2.

FIGURE XV

STRAIN VERSUS LOCATION FOR PANEL 1 AT 40,000 POUND LOAD



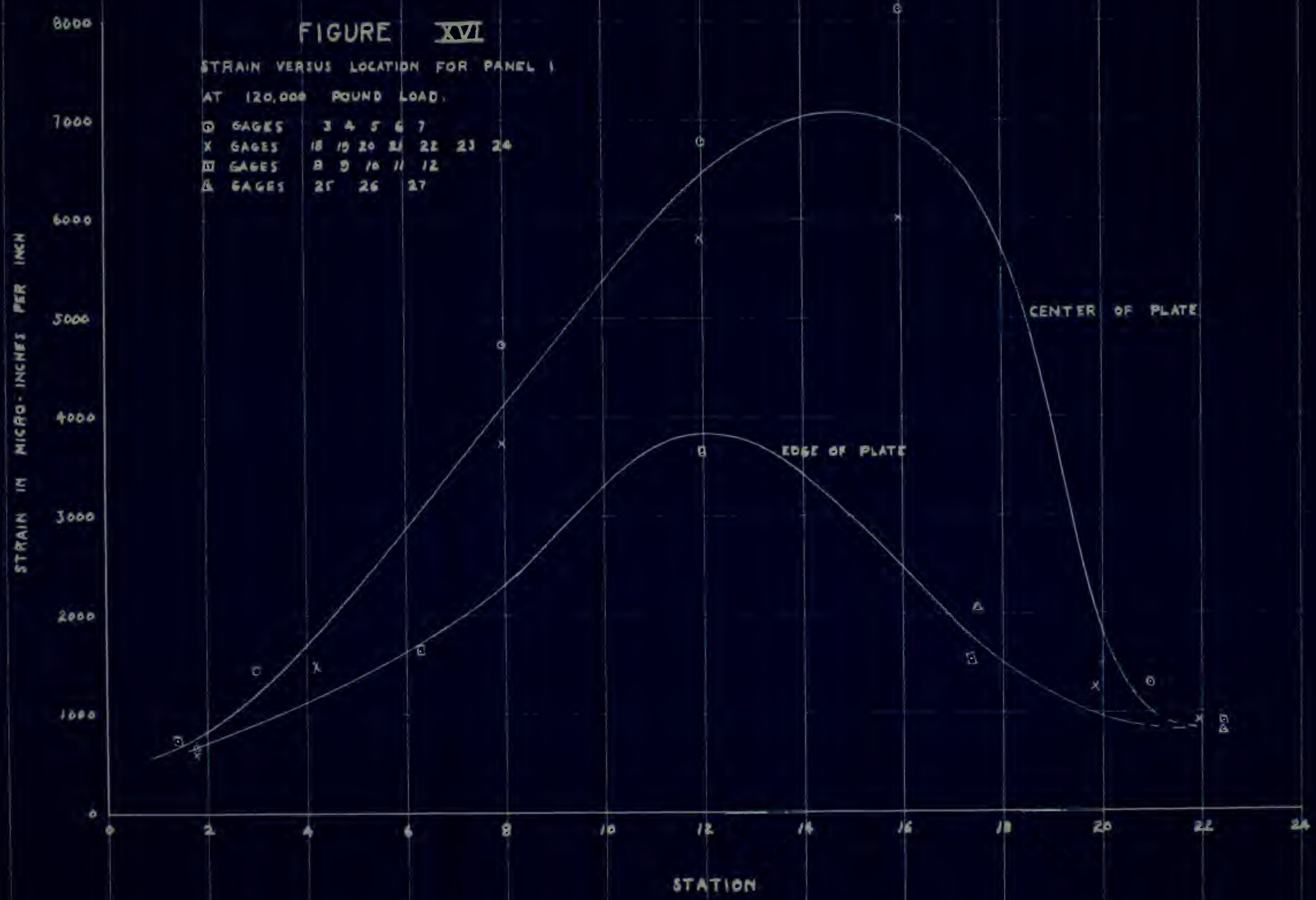


FIGURE XVI

STRAIN VERSUS LOCATION FOR PANEL 1 AT 120,000 POUND LOAD.

FIGURE XVII

STRAIN VERSUS LOCATION FOR PANEL 2 AT 40,000 POUND LOAD.

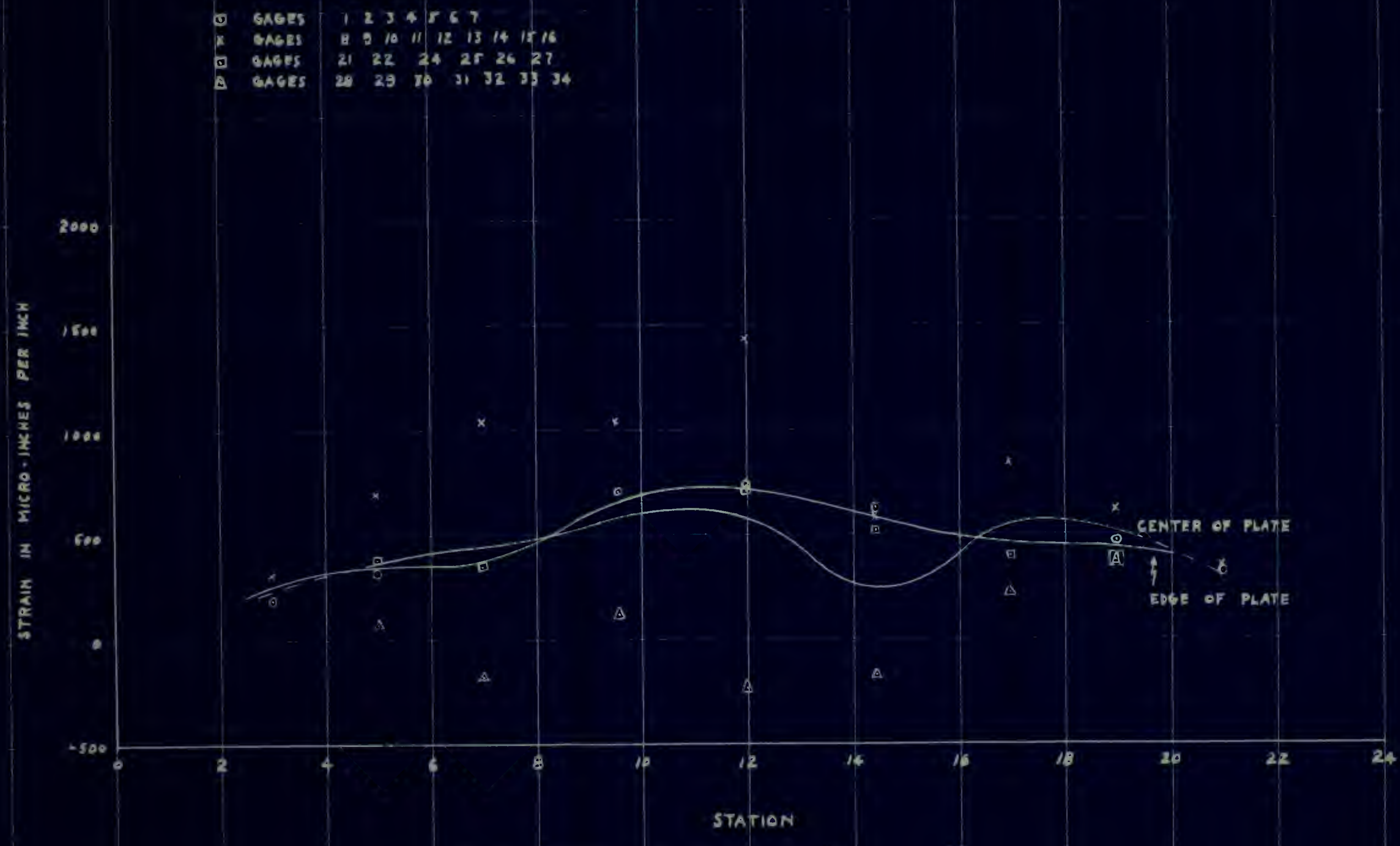


FIGURE XVIII

STRAIN VERSUS LOCATION FOR PANEL ℄ AT 120,000 POUND LOAD.

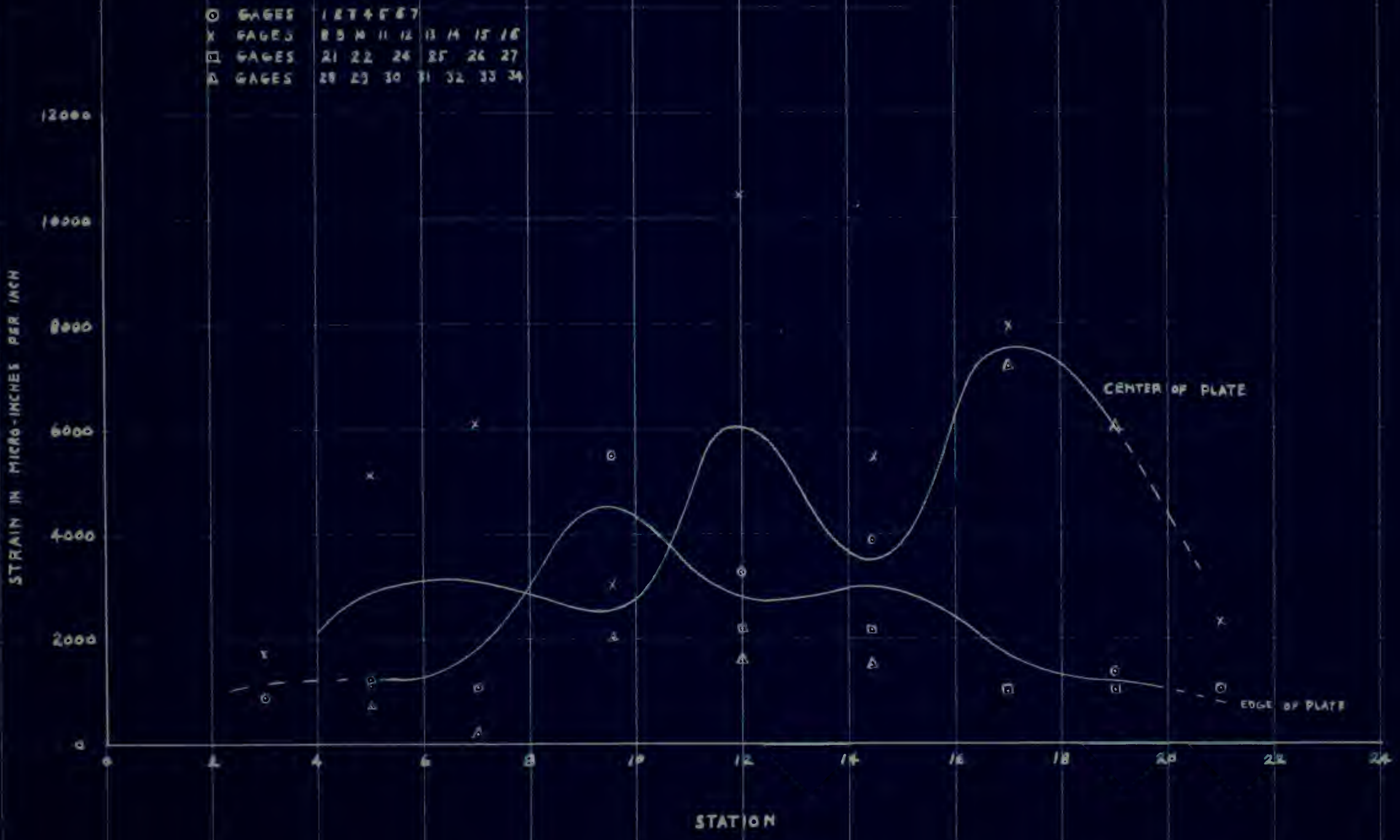


FIGURE XIX
CROSS-CURVE AT STATION 4
FOR PANEL 1

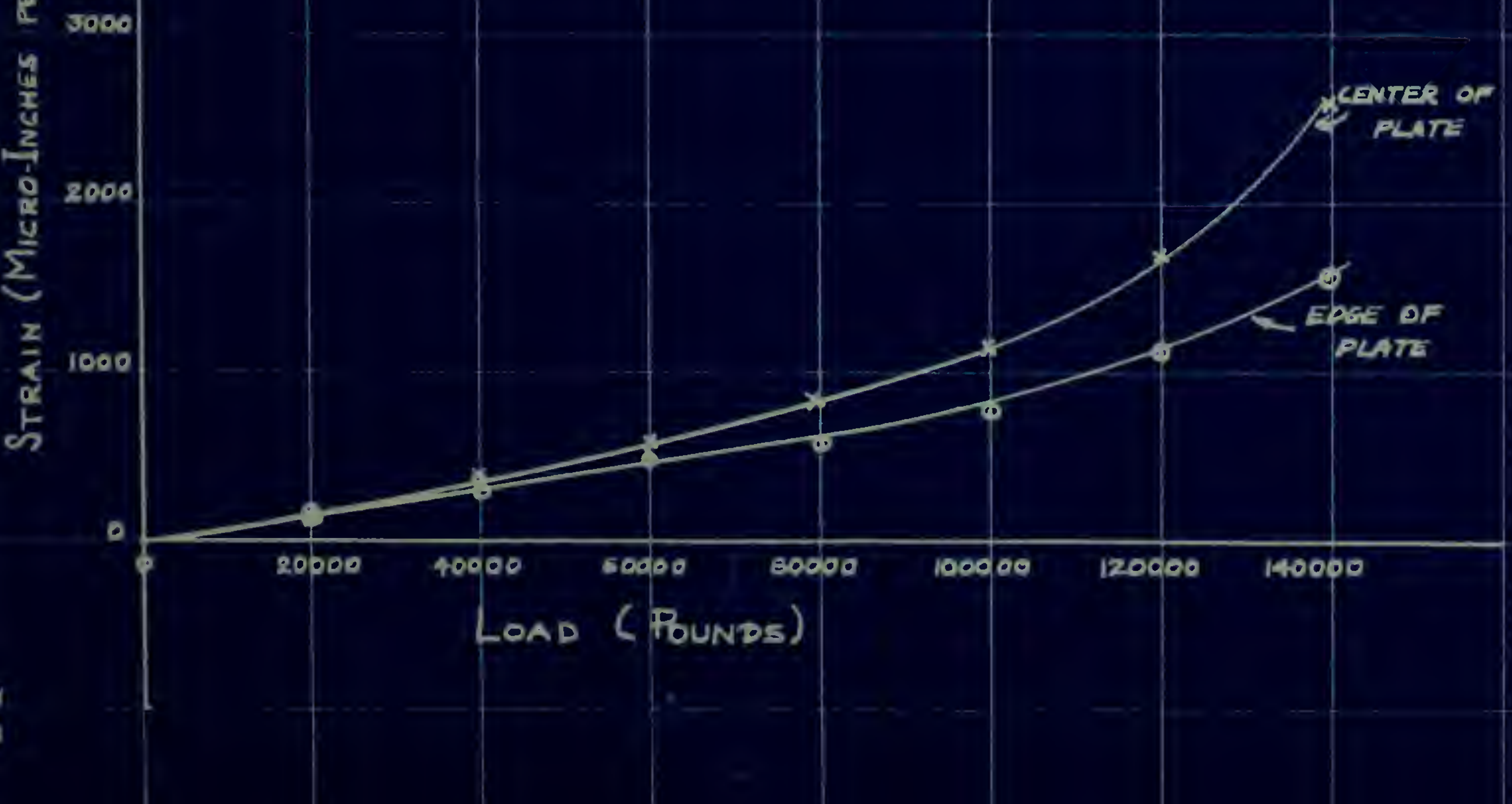


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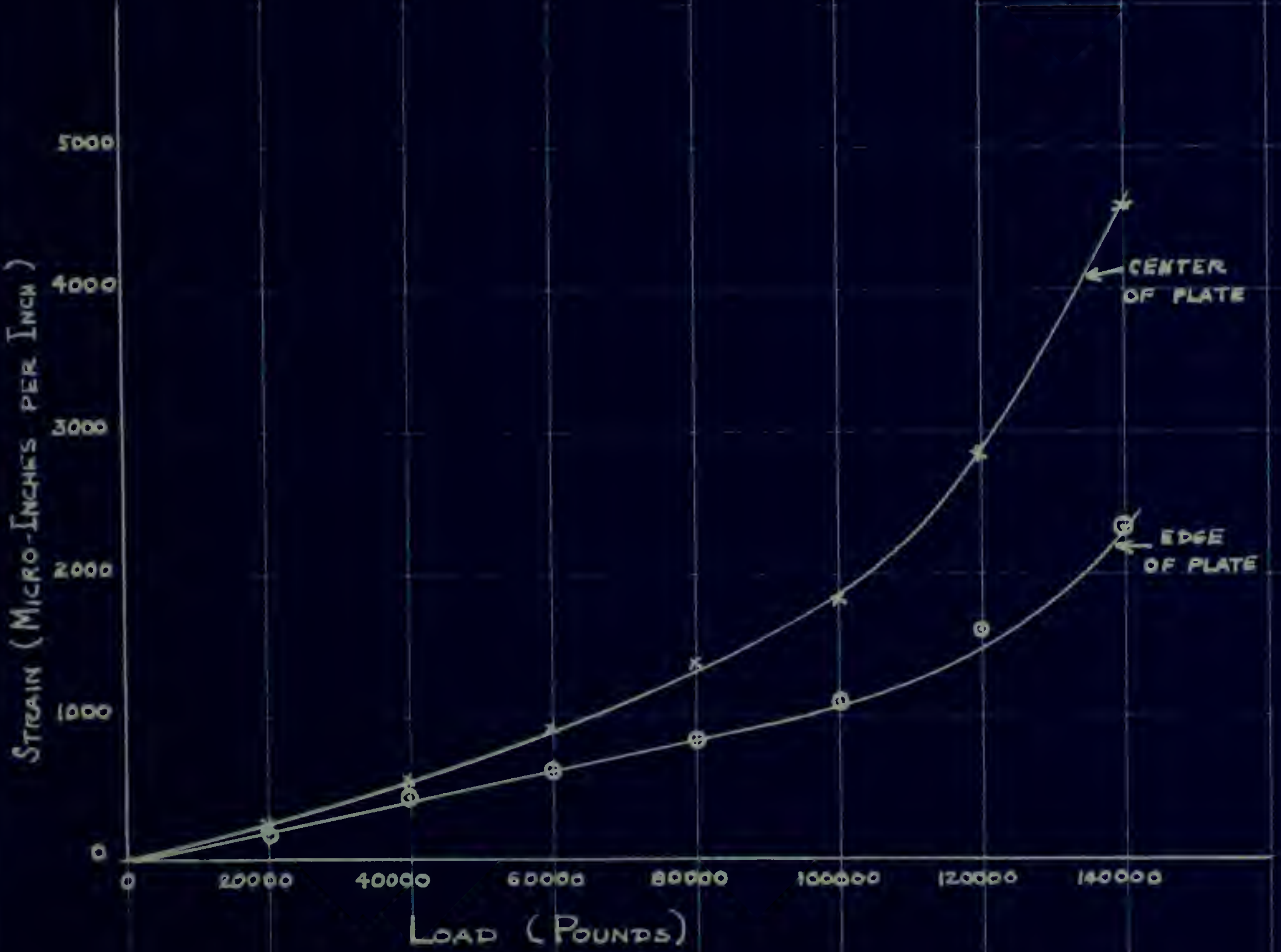
FIGURE XI

CROSS-CURVE AT STATION 6
FOR PANEL 1



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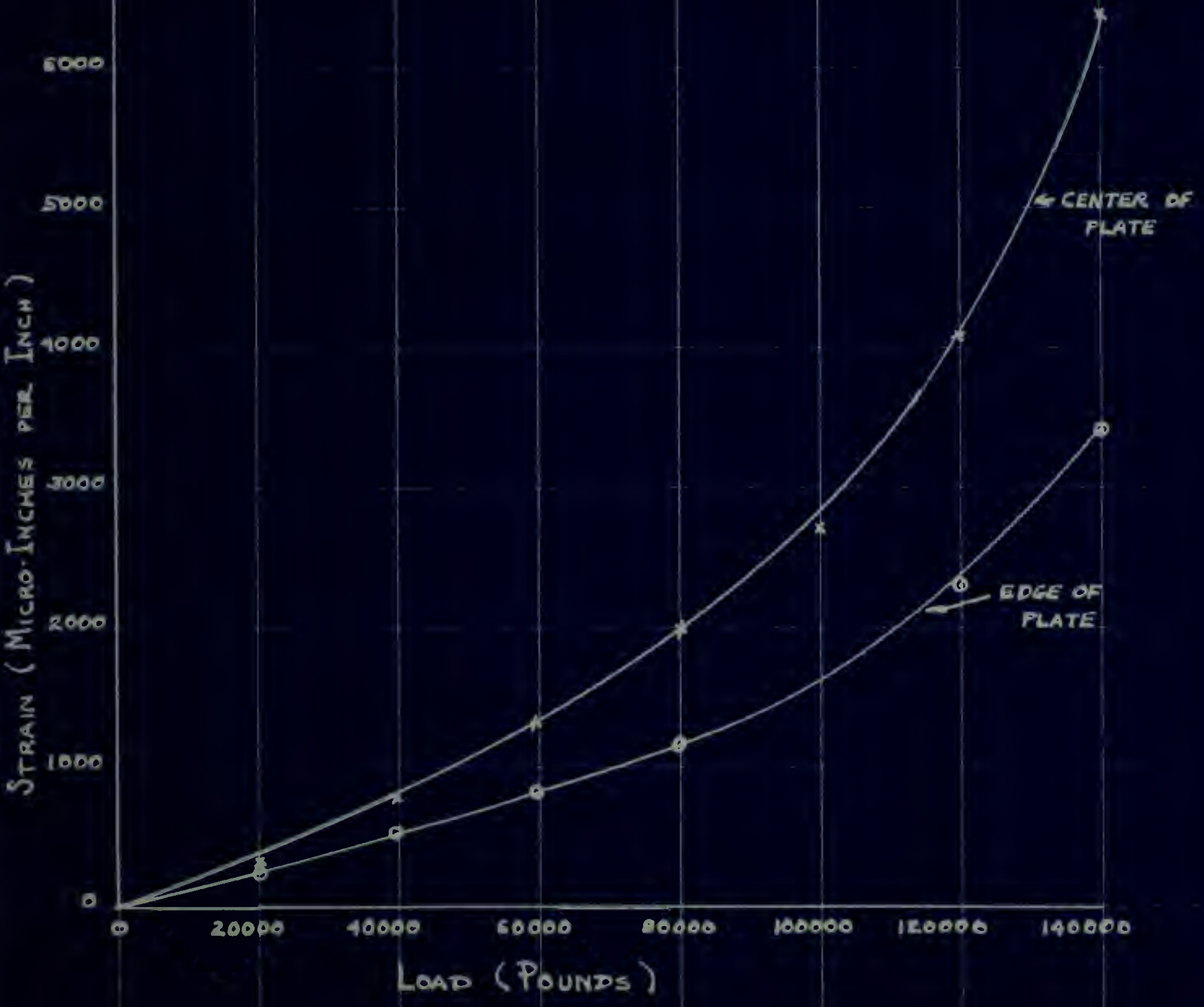
# FIGURE XXI
# CROSS-CURVE AT STATION 8
# FOR PANEL 1



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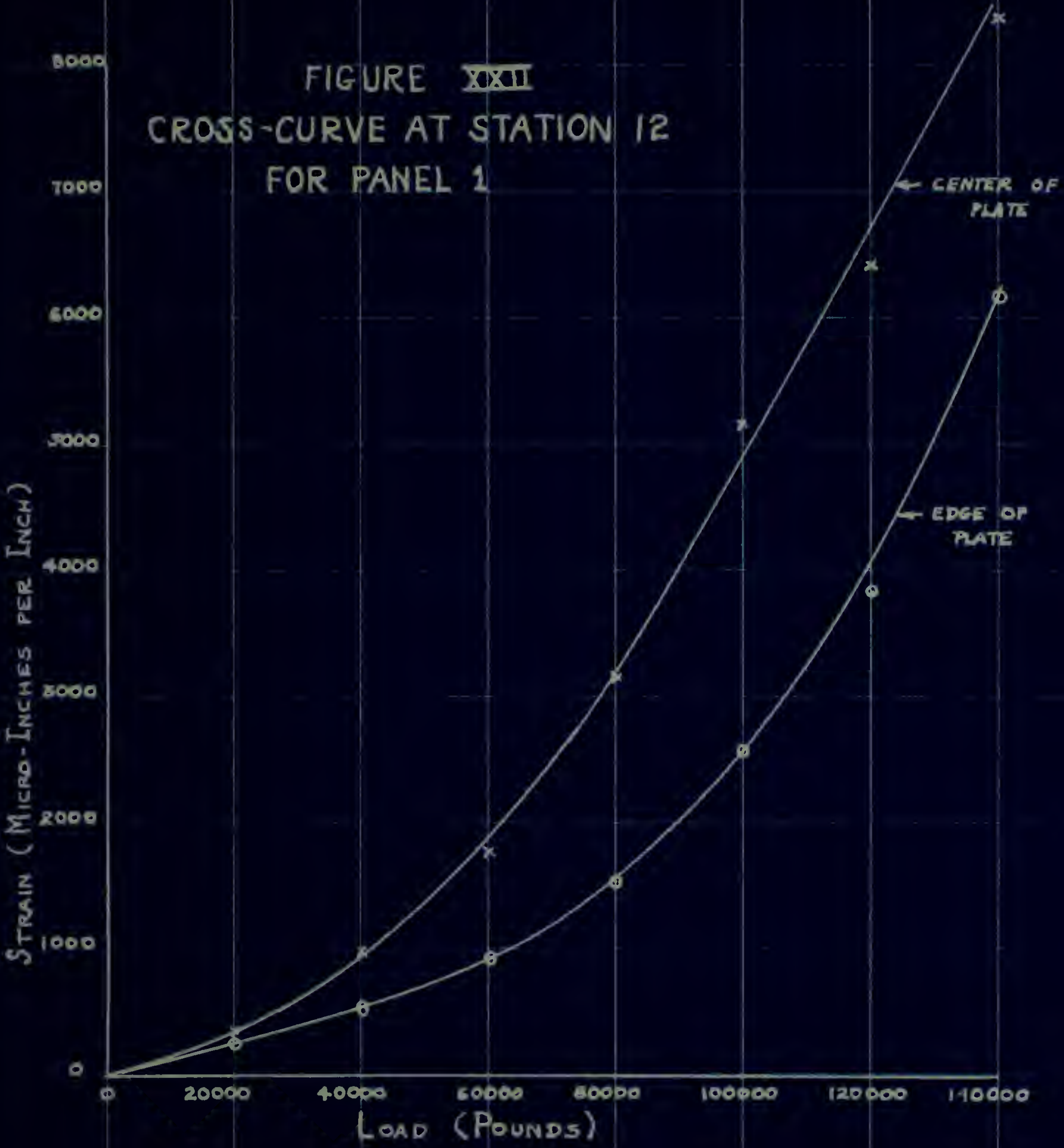

FIGURE XXII
CROSS-CURVE AT STATION 12
FOR PANEL 1

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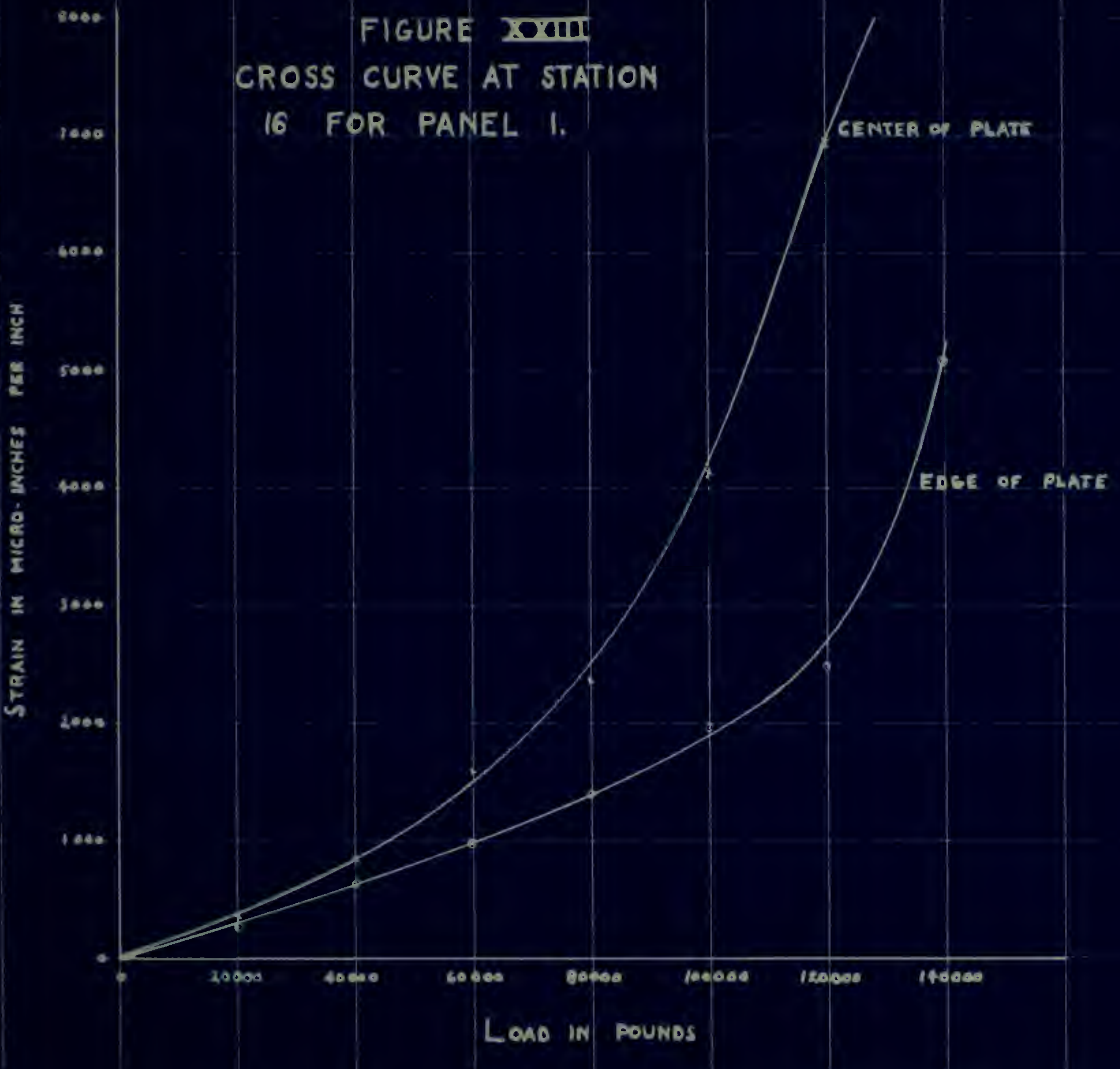
FIGURE XVIII
CROSS CURVE AT STATION
16 FOR PANEL 1.



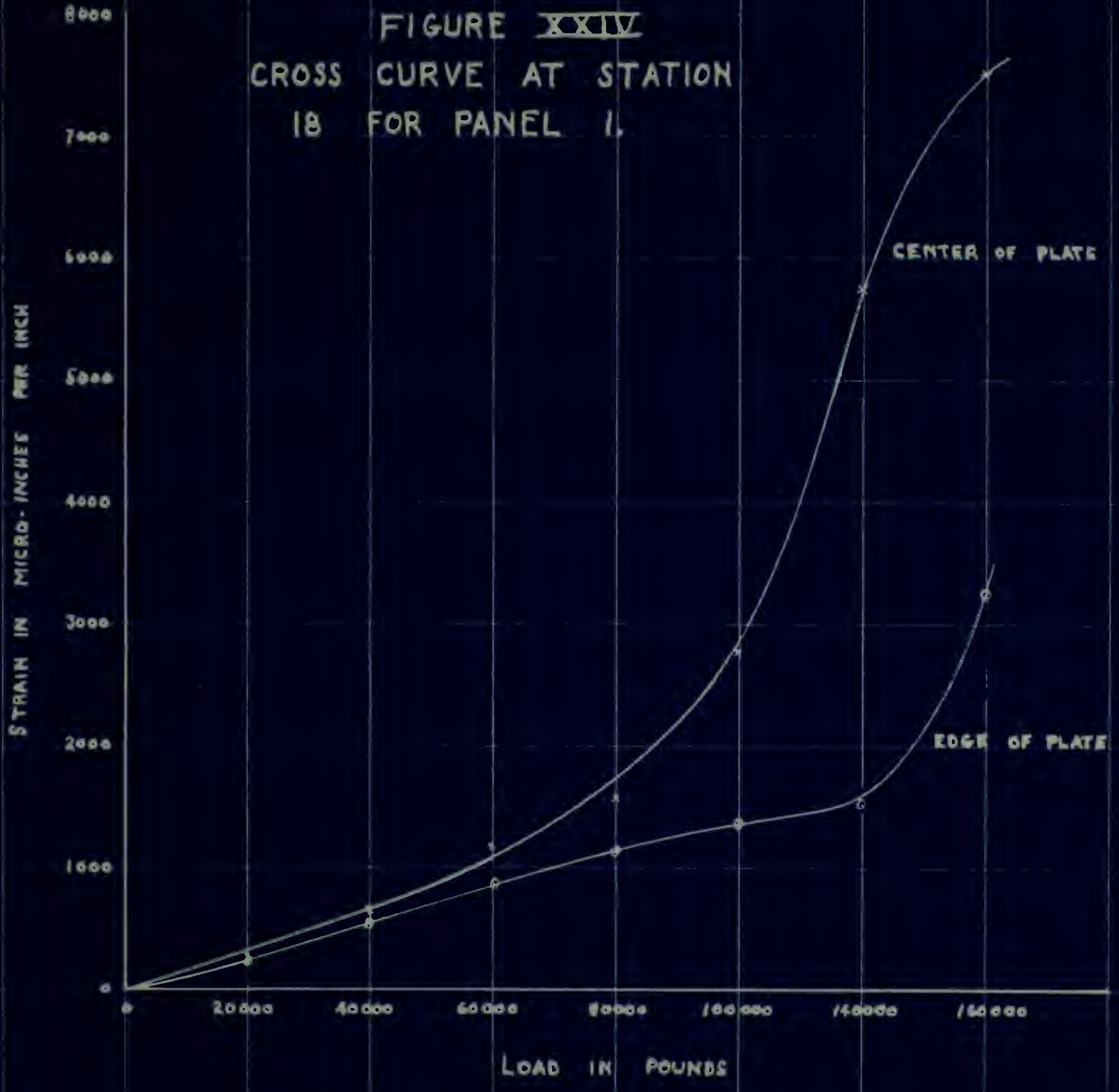
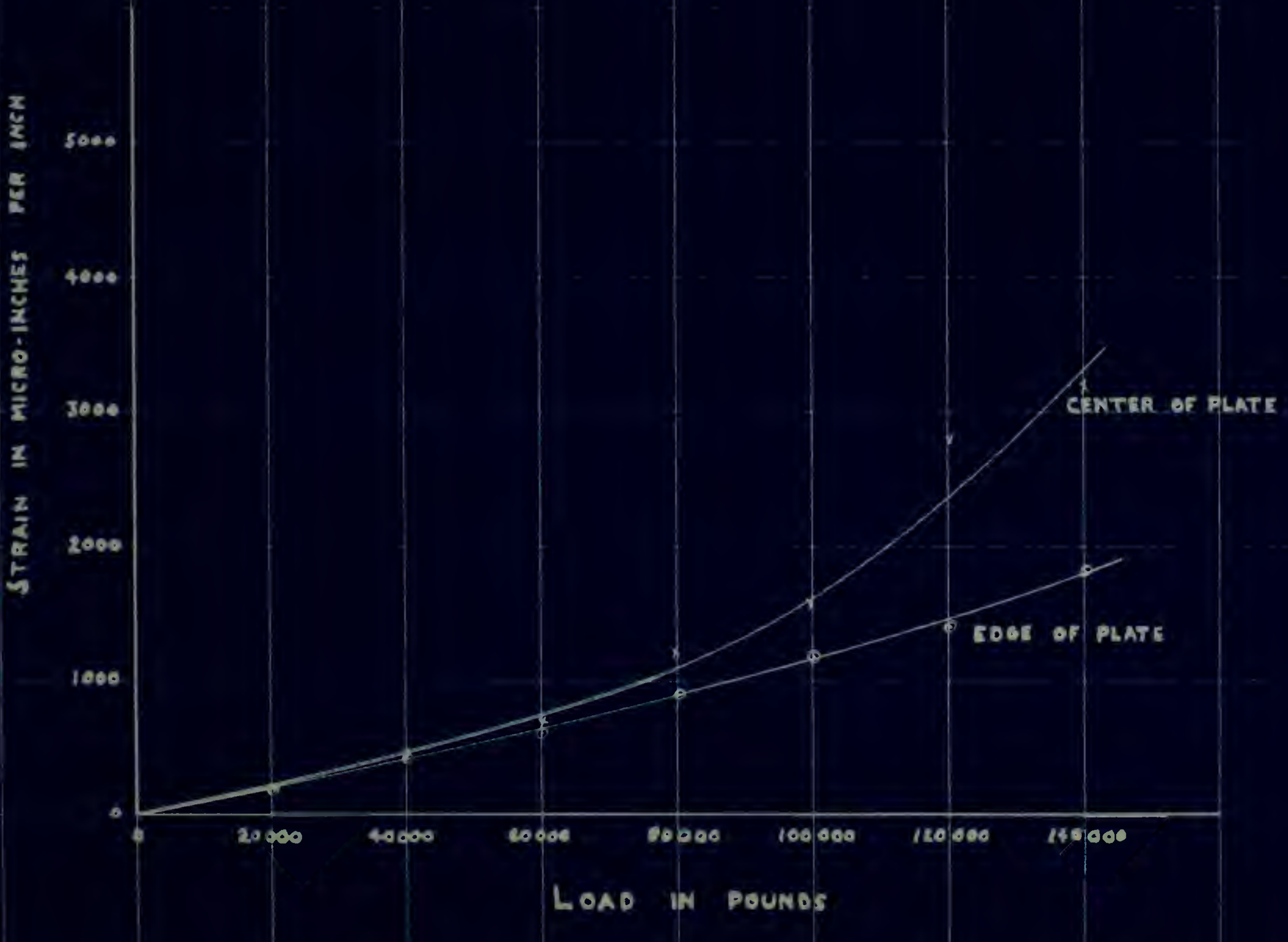


FIGURE XXIV
CROSS CURVE AT STATION
18 FOR PANEL 1.

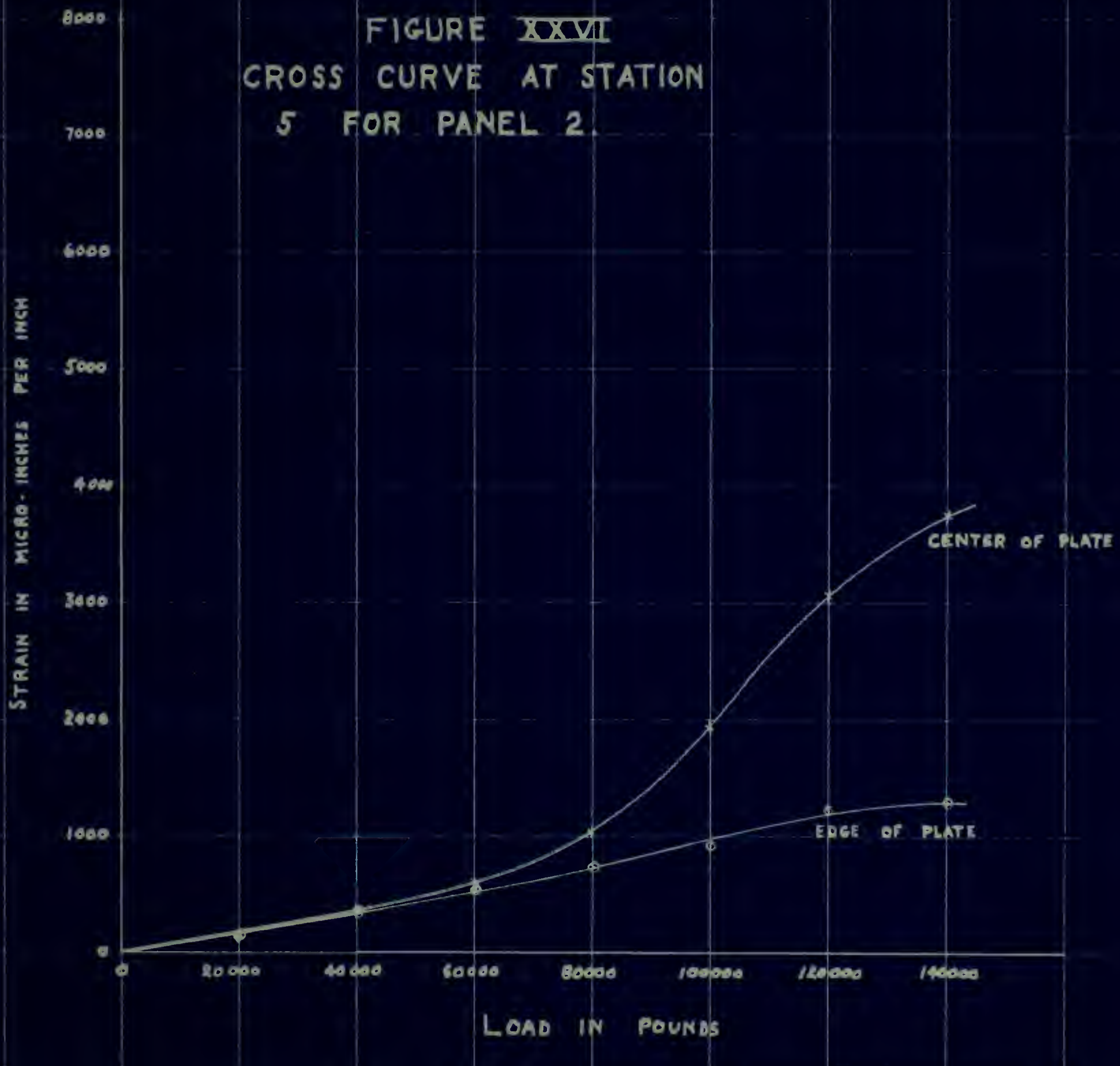
FIGURE XXV

CROSS CURVE AT STATION 20 FOR PANEL I.



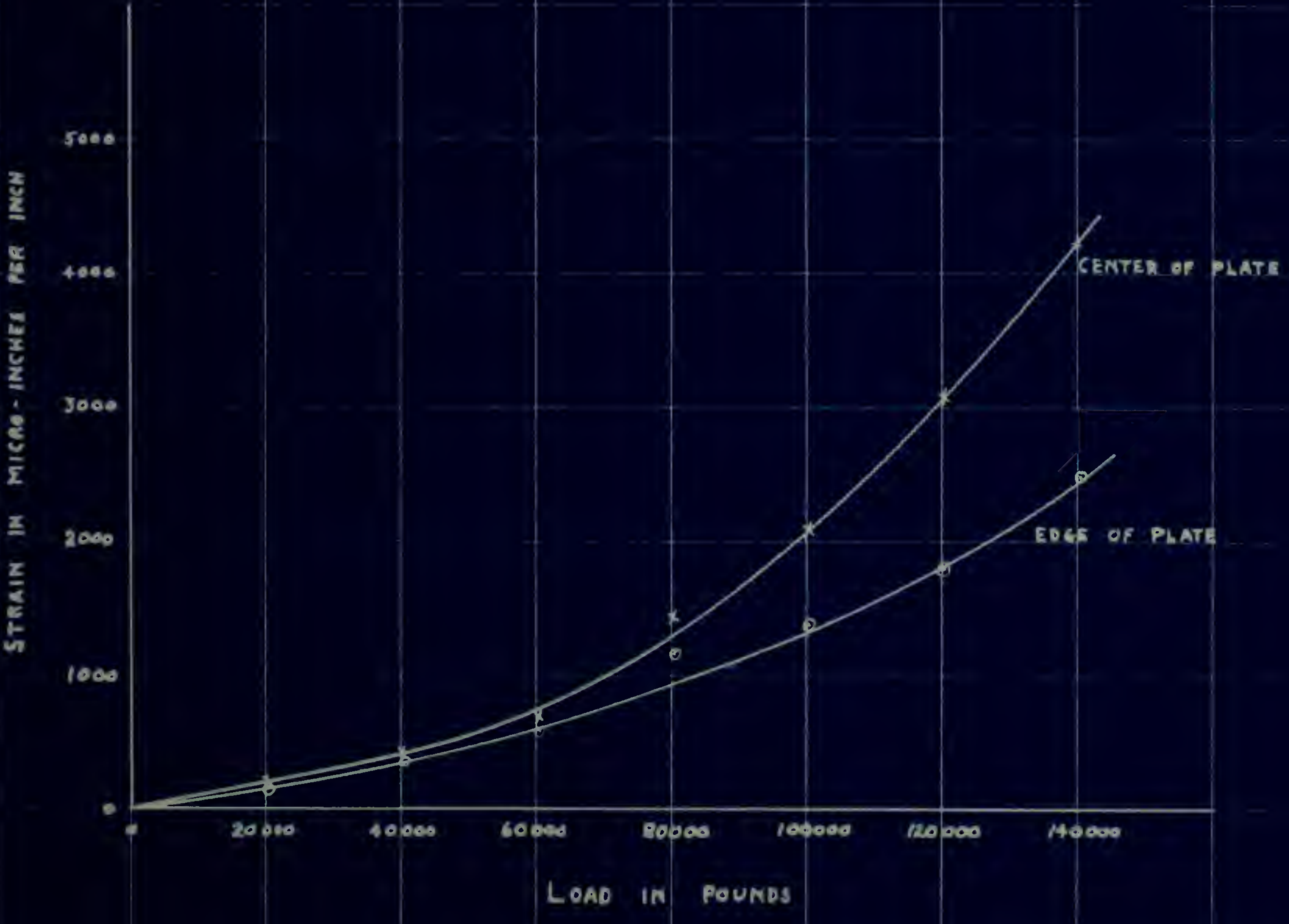
## FIGURE XXVI

CROSS CURVE AT STATION 5 FOR PANEL 2.



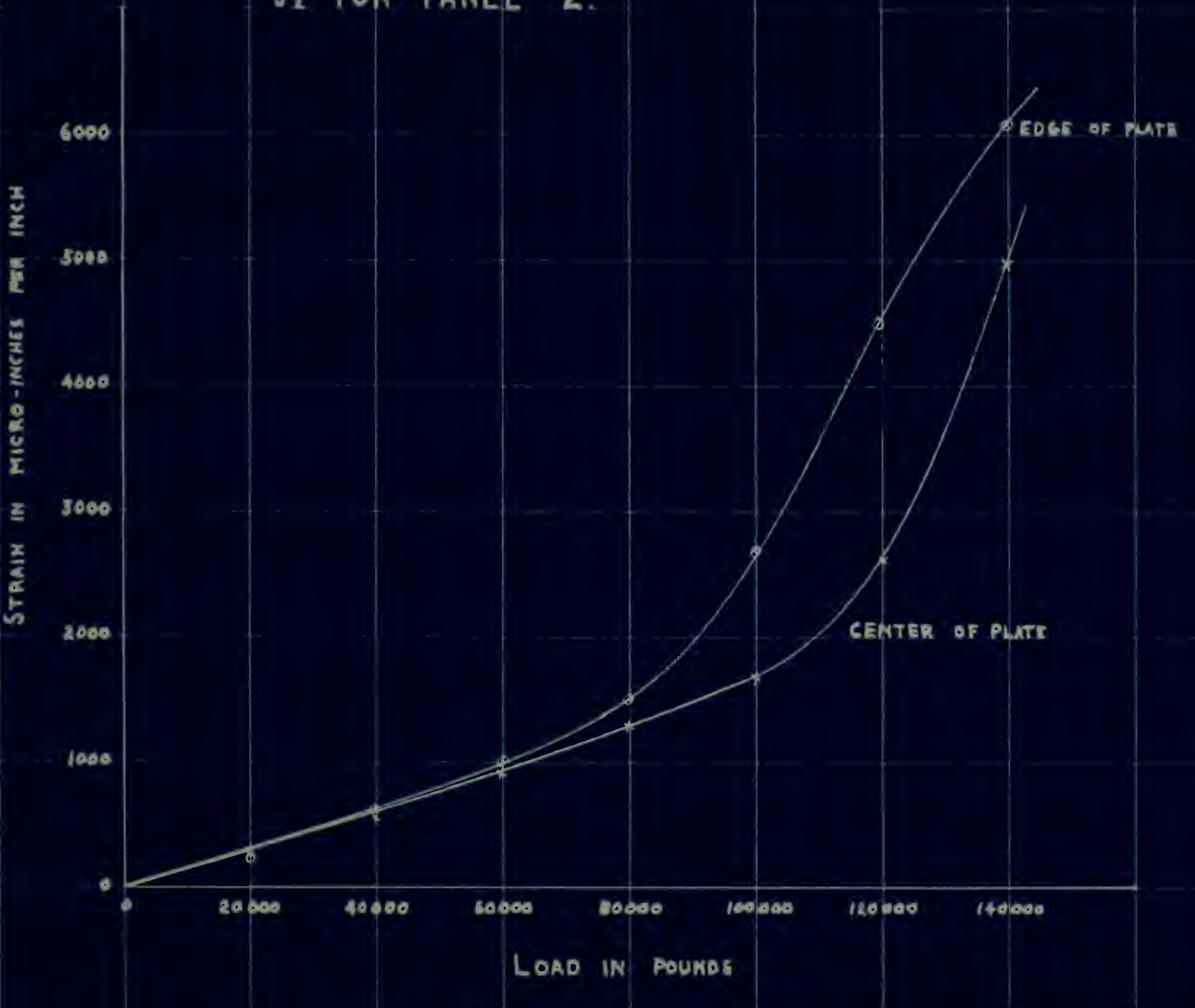
## FIGURE XXVII

CROSS CURVE AT STATION 7 FOR PANEL 2.



## FIGURE XXVIII

## CROSS CURVE AT STATION 9½ FOR PANEL 2.



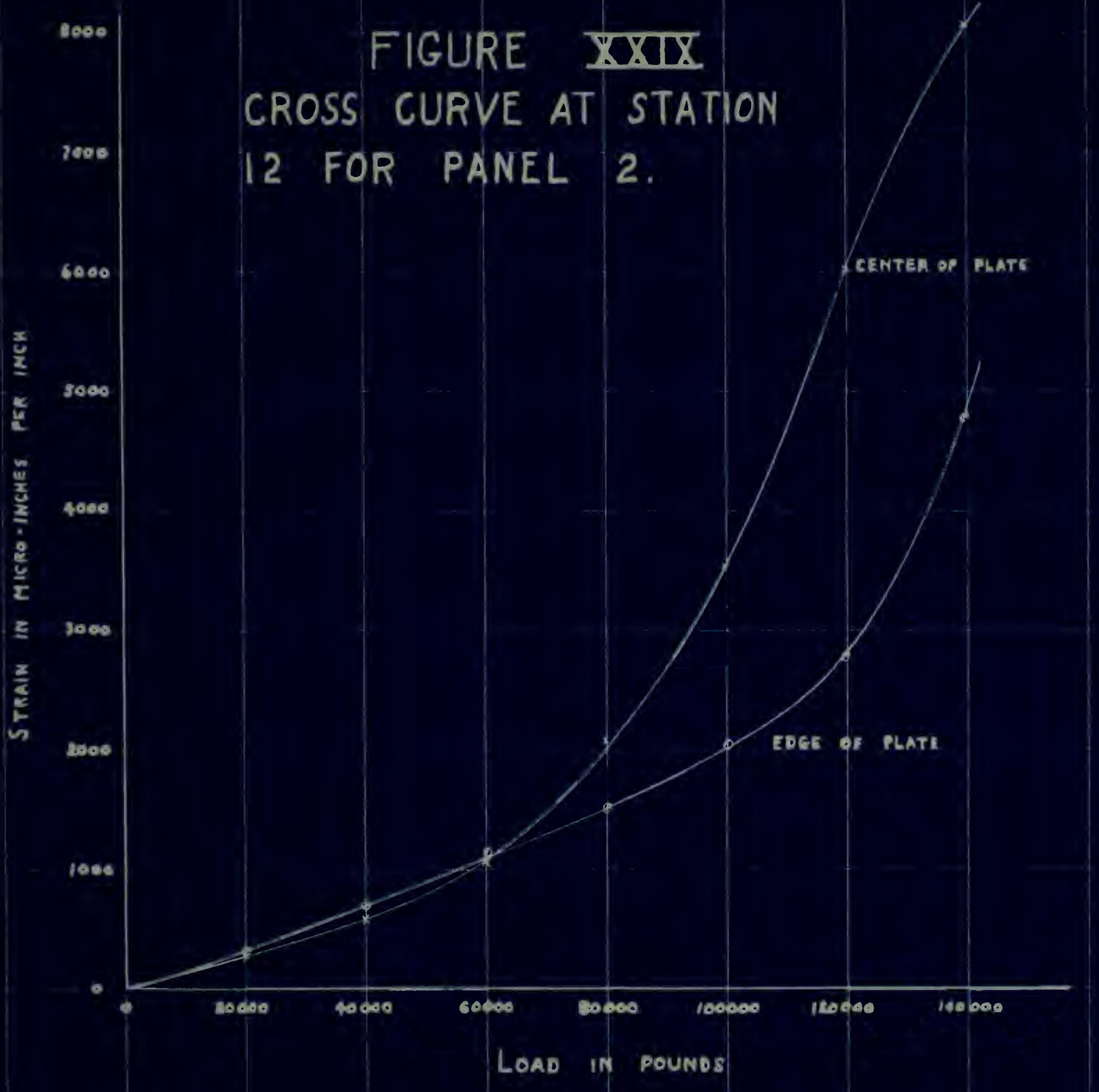
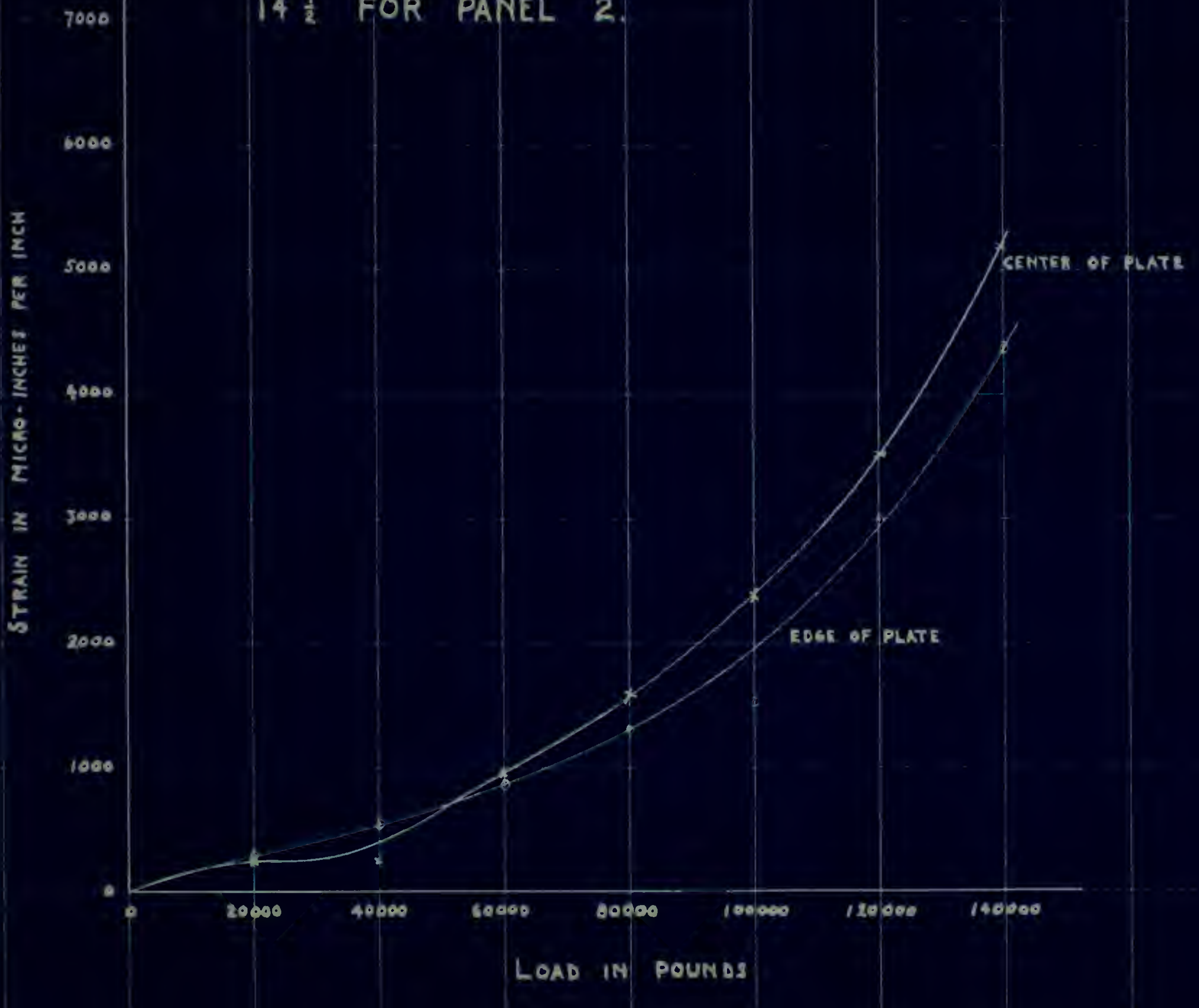


FIGURE XXIX
CROSS CURVE AT STATION
12 FOR PANEL 2.

FIGURE XXX
CROSS CURVE AT STATION
14 ½ FOR PANEL 2.



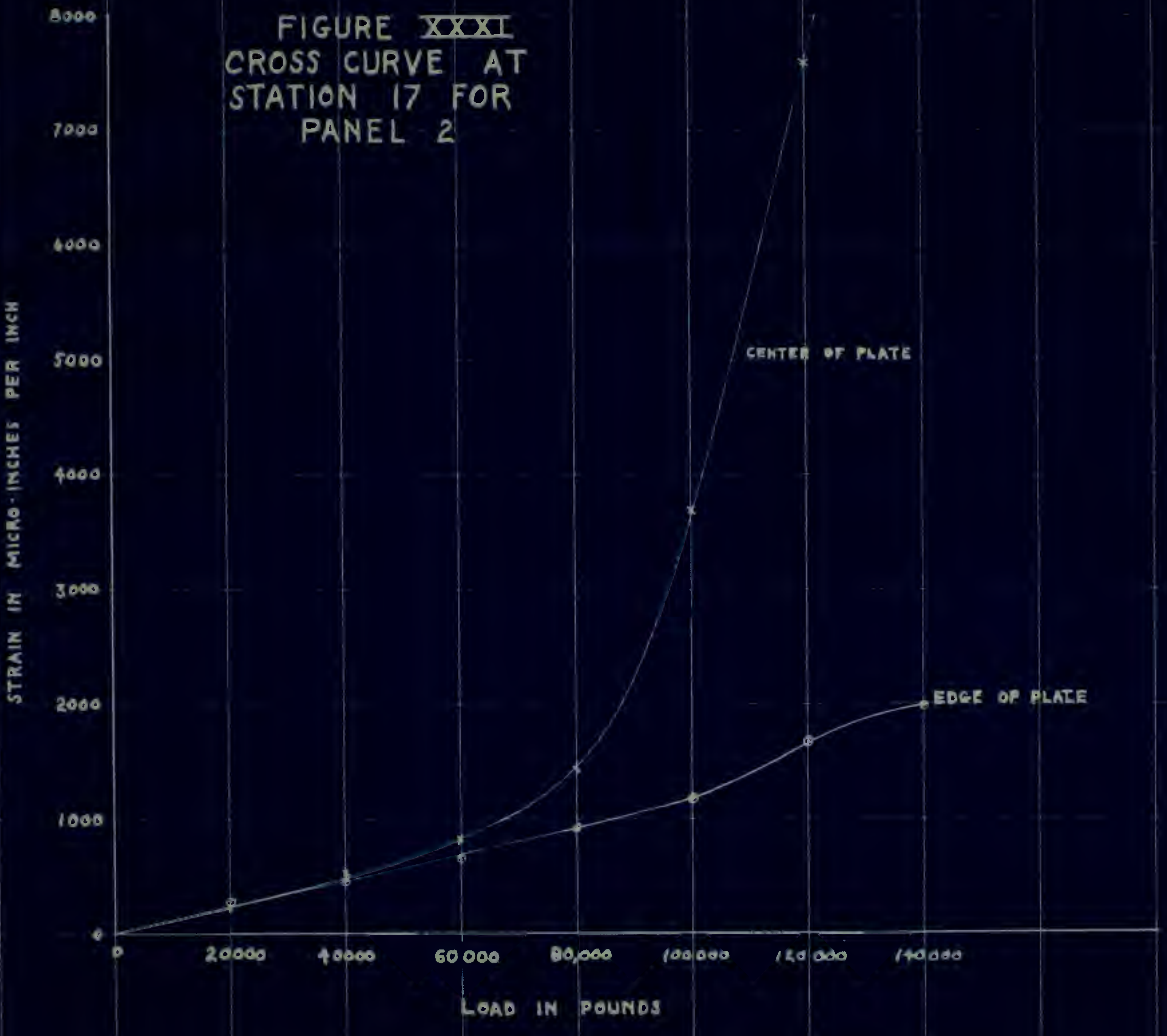


FIGURE XXXI
CROSS CURVE AT
STATION 17 FOR
PANEL 2

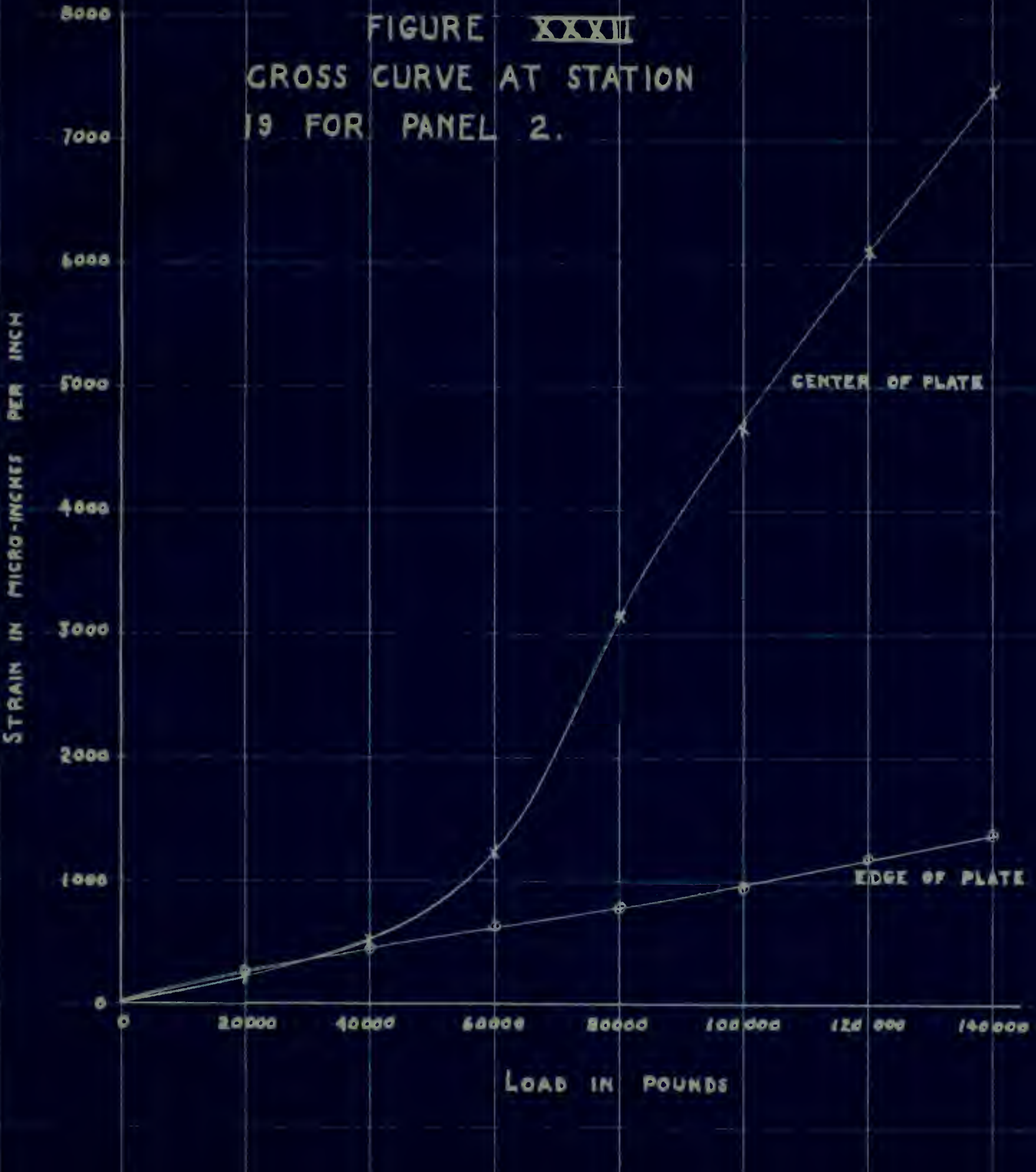


FIGURE XXXII
CROSS CURVE AT STATION 19 FOR PANEL 2.

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# FIGURE XXXIII

PANEL I WITH UNIFORM STRAIN OF 500 MICRO-INCHES PER INCH IN EDGE (14,000 PSI) SHOWING MID-PANEL MID-THICKNESS STRESSES AND STRAINS.

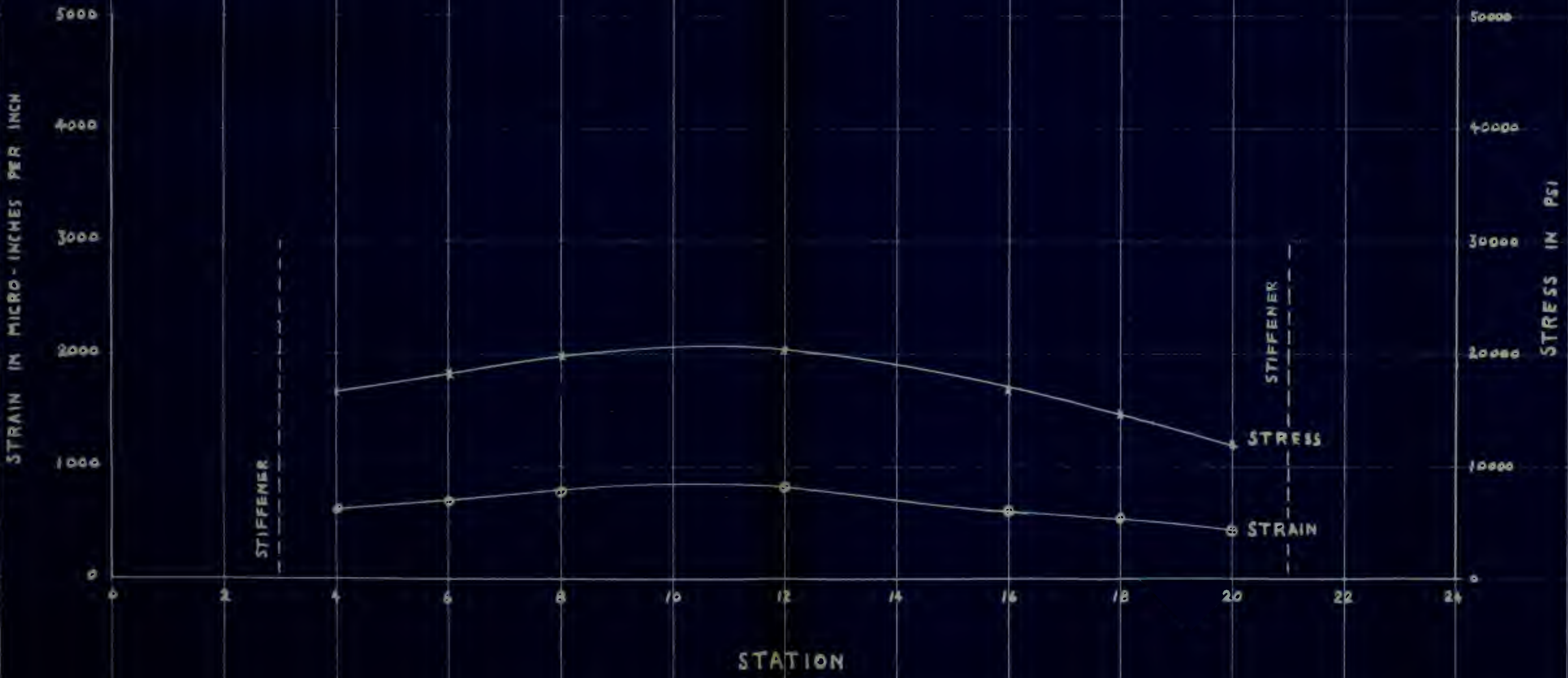


FIGURE XXXIV

PANEL 1 WITH UNIFORM STRAIN OF 1000 MICRO-INCHES PER INCH IN EDGE (24,000 PSI) SHOWING MID-PANEL MID-THICKNESS STRESSES AND STRAINS.

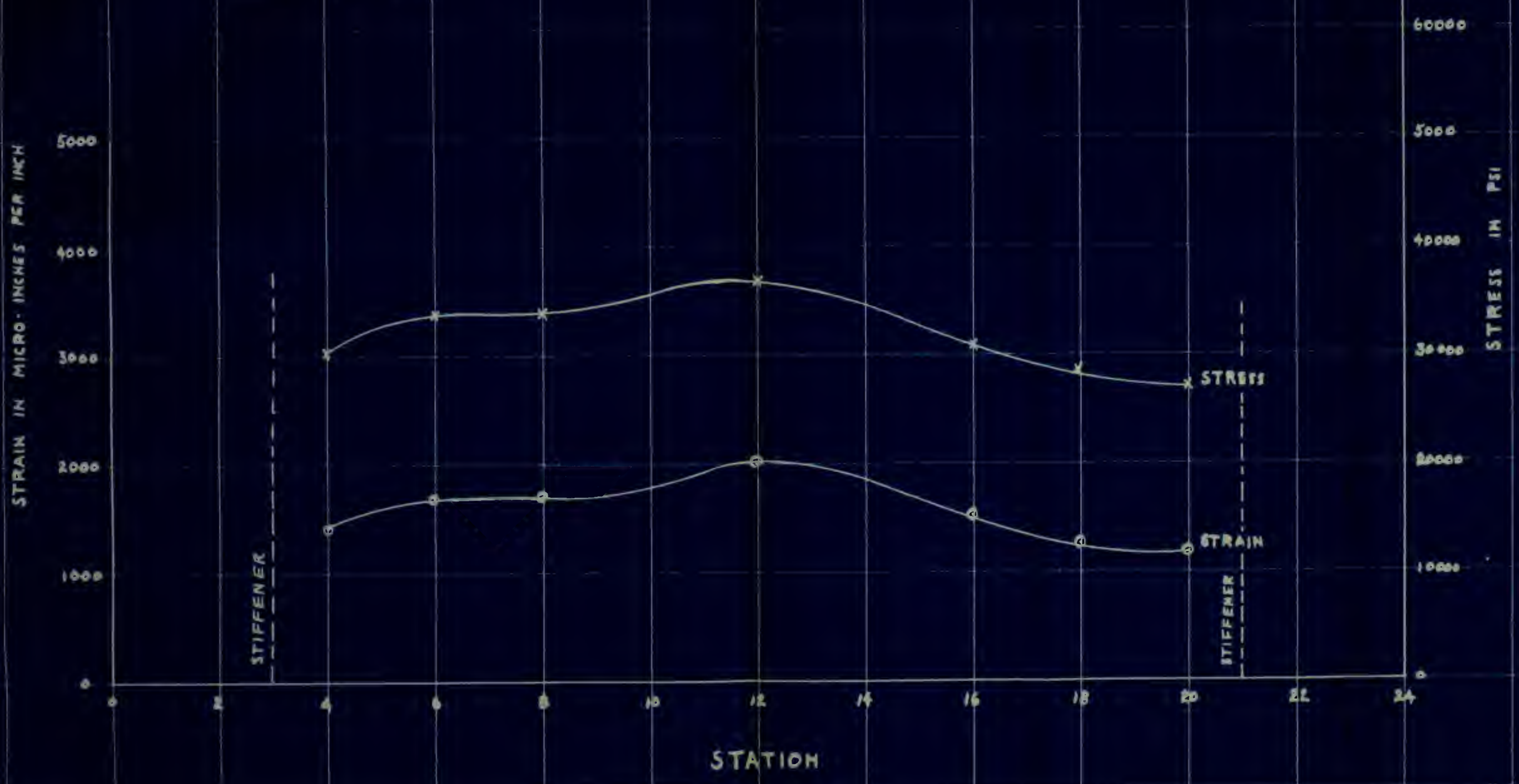
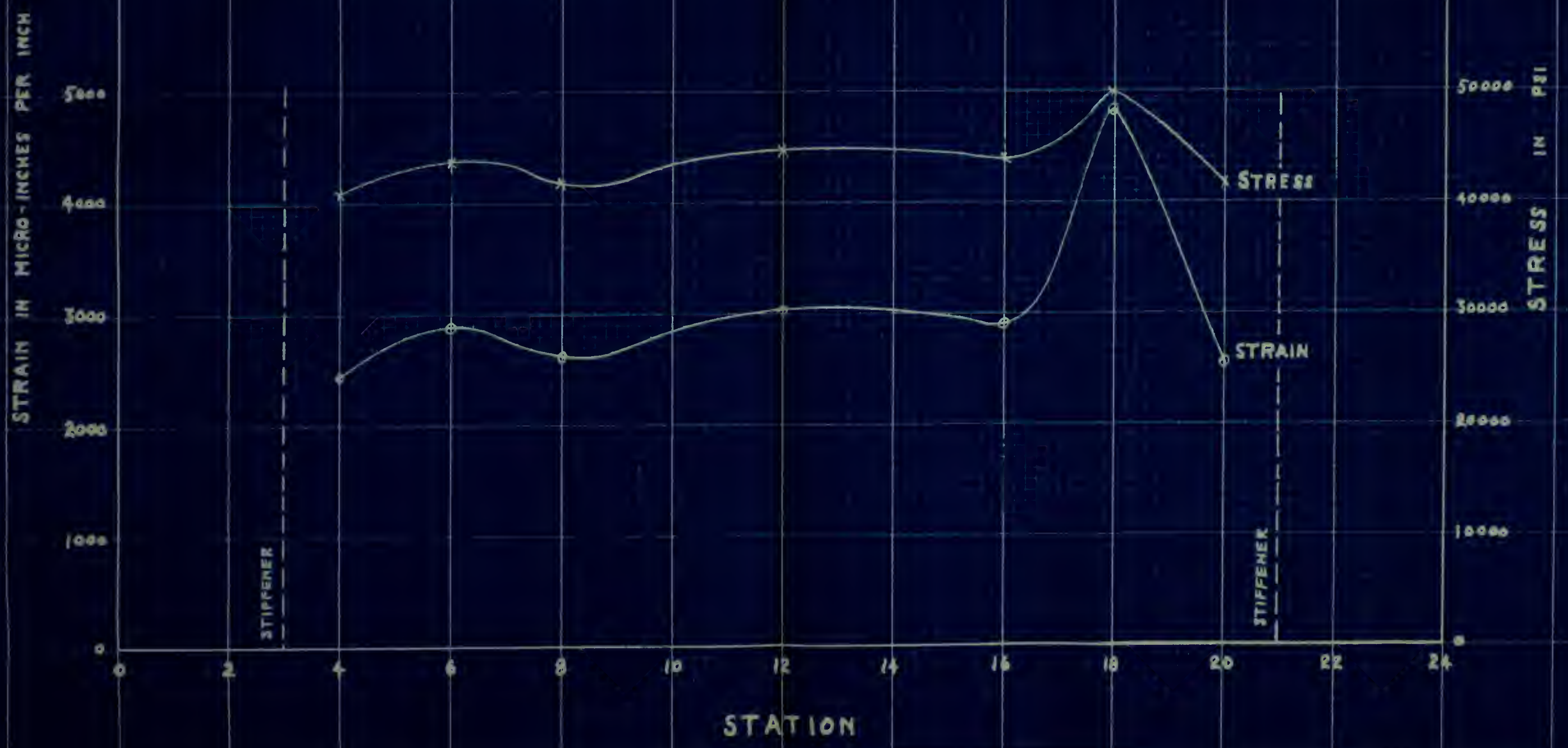


FIGURE XXXV

PANEL 1 WITH UNIFORM STRAIN OF 1500 MICRO-INCHES PER INCH IN EDGE (31,400 PSI) SHOWING MID-PANEL MID-THICKNESS STRESSES AND STRAINS.



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# FIGURE XXXVI

PANEL I WITH UNIFORM STRAIN OF 2000 MICRO-INCHES PER INCH IN EDGE (37,000 PSI) SHOWING MID-PANEL MID-THICKNESS STRESSES AND STRAINS.

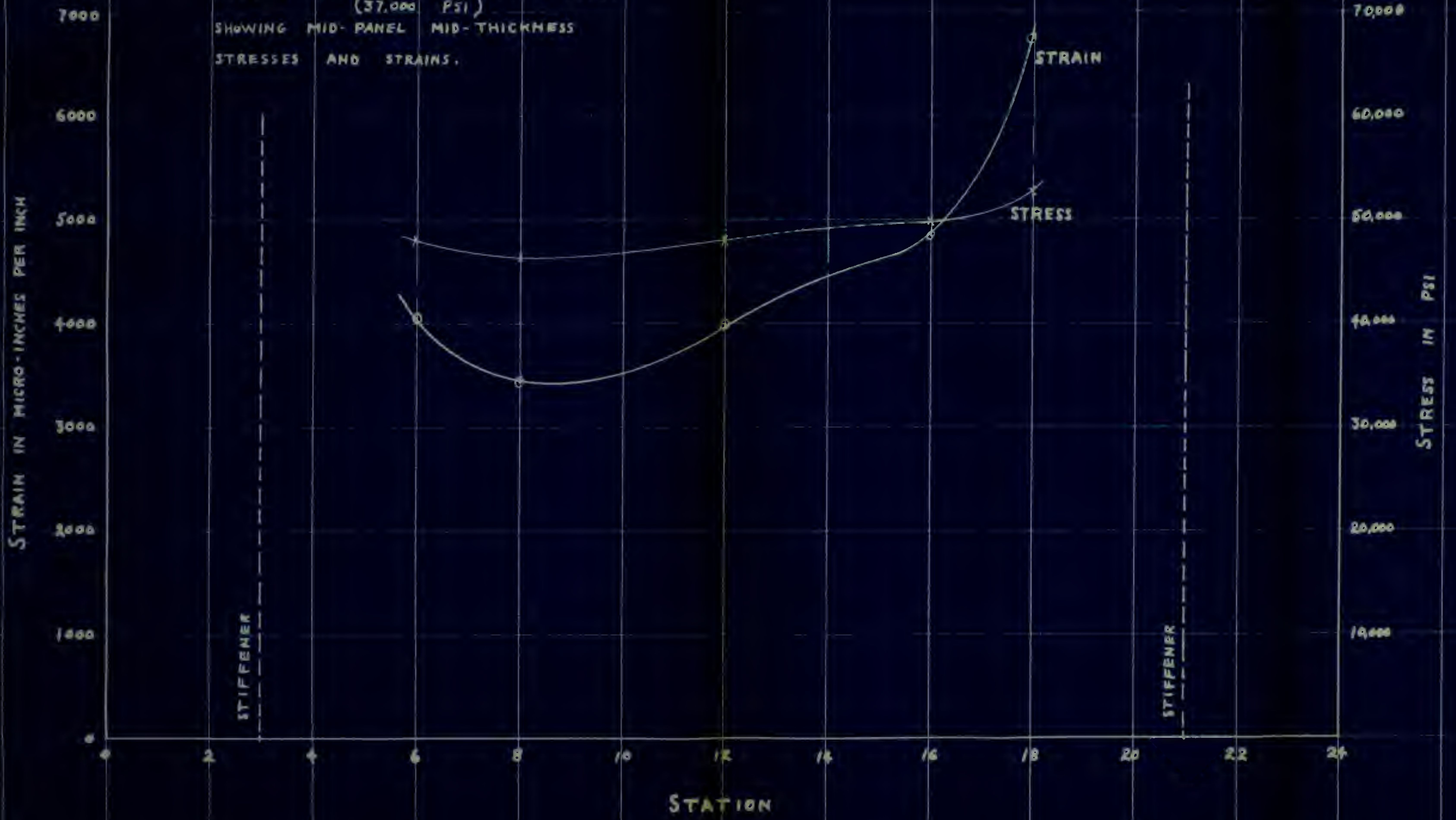


FIGURE XXXVII

PANEL 2 WITH UNIFORM STRAIN OF 500 MICRO-INCHES PER INCH IN EDGE (14,000 PSI) SHOWING MID-PANEL MID-THICKNESS STRESSES AND STRAIN.

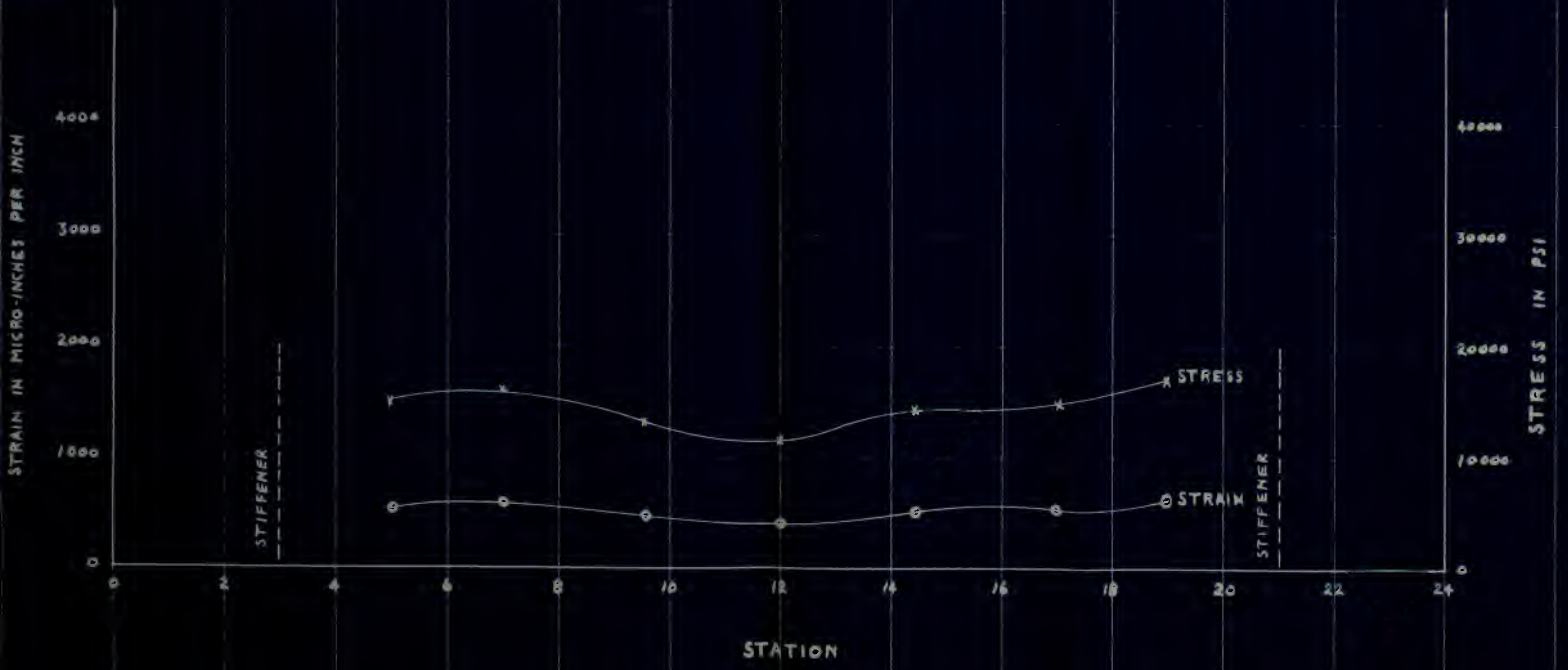


FIGURE XXXVIII

PANEL 2 WITH UNIFORM STRAIN OF 1000 MICRO-INCHES PER INCH IN EDGE (24,000 PSI) SHOWING MID-PANEL MID-THICKNESS STRESSES AND STRAINS

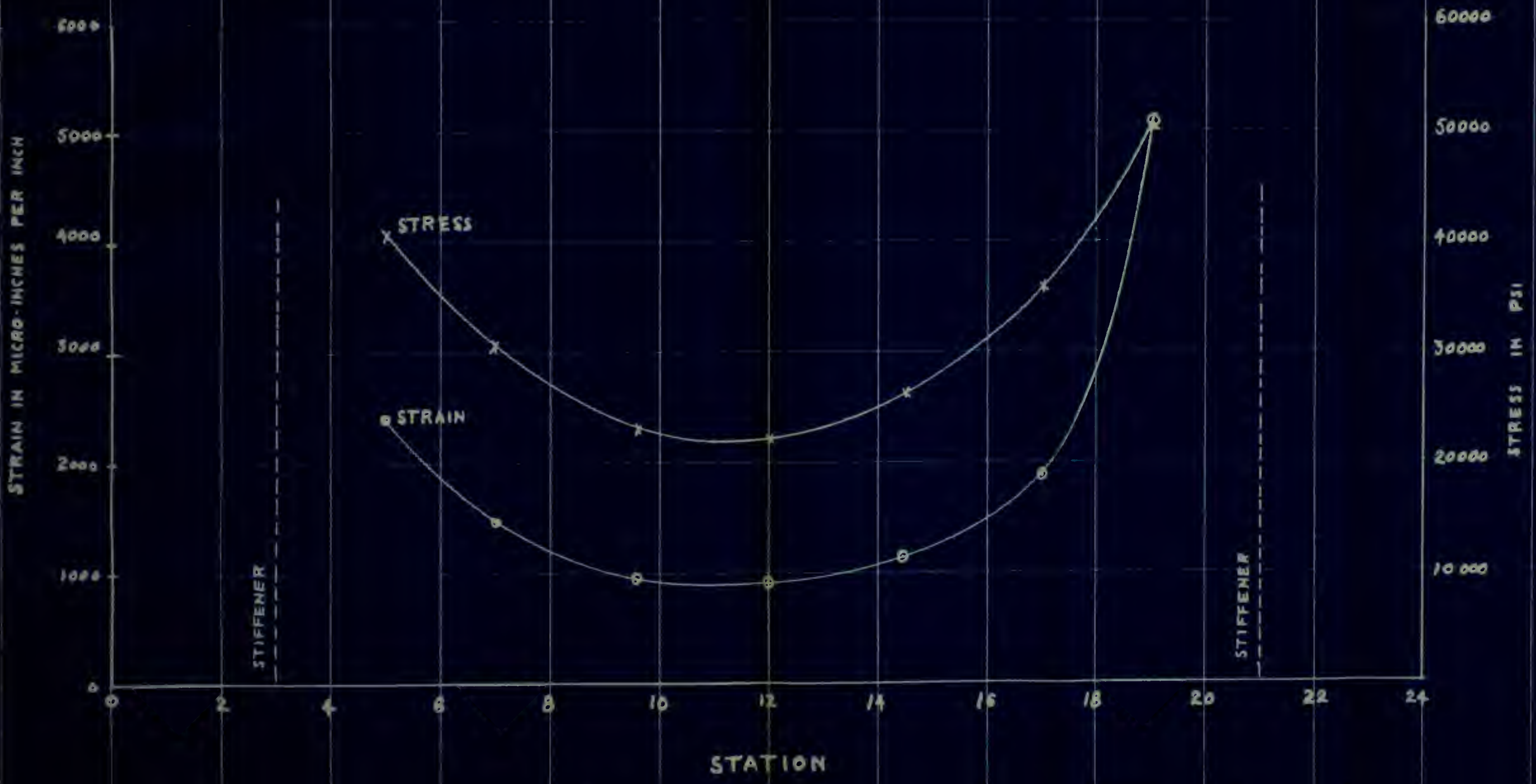
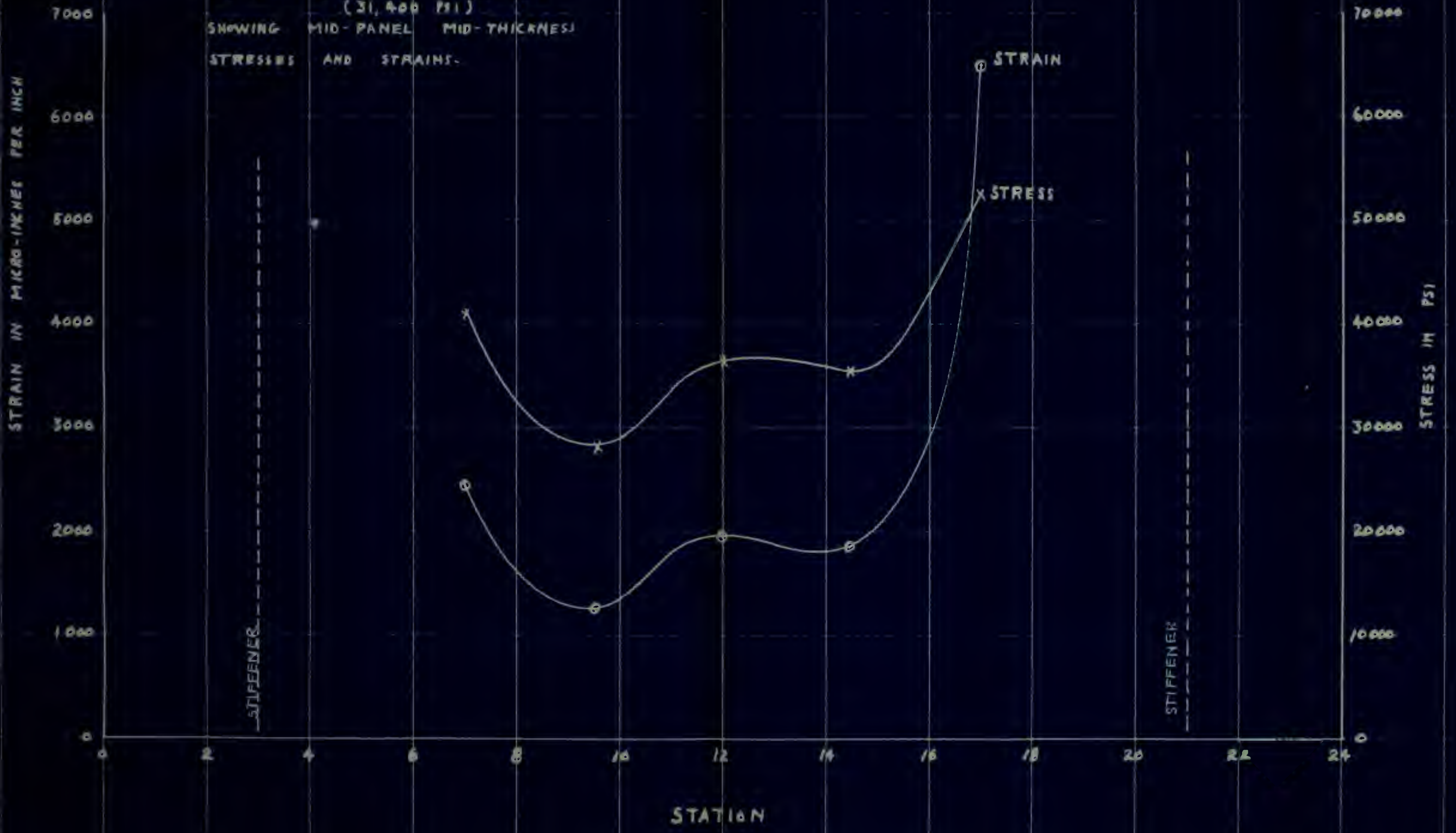


FIGURE XXXIX

PANEL 2 WITH UNIFORM STRAIN OF 1500 MICRO-INCHES PER INCH IN EDGE (31,400 PSI) SHOWING MID-PANEL MID-THICKNESS STRESSES AND STRAINS.



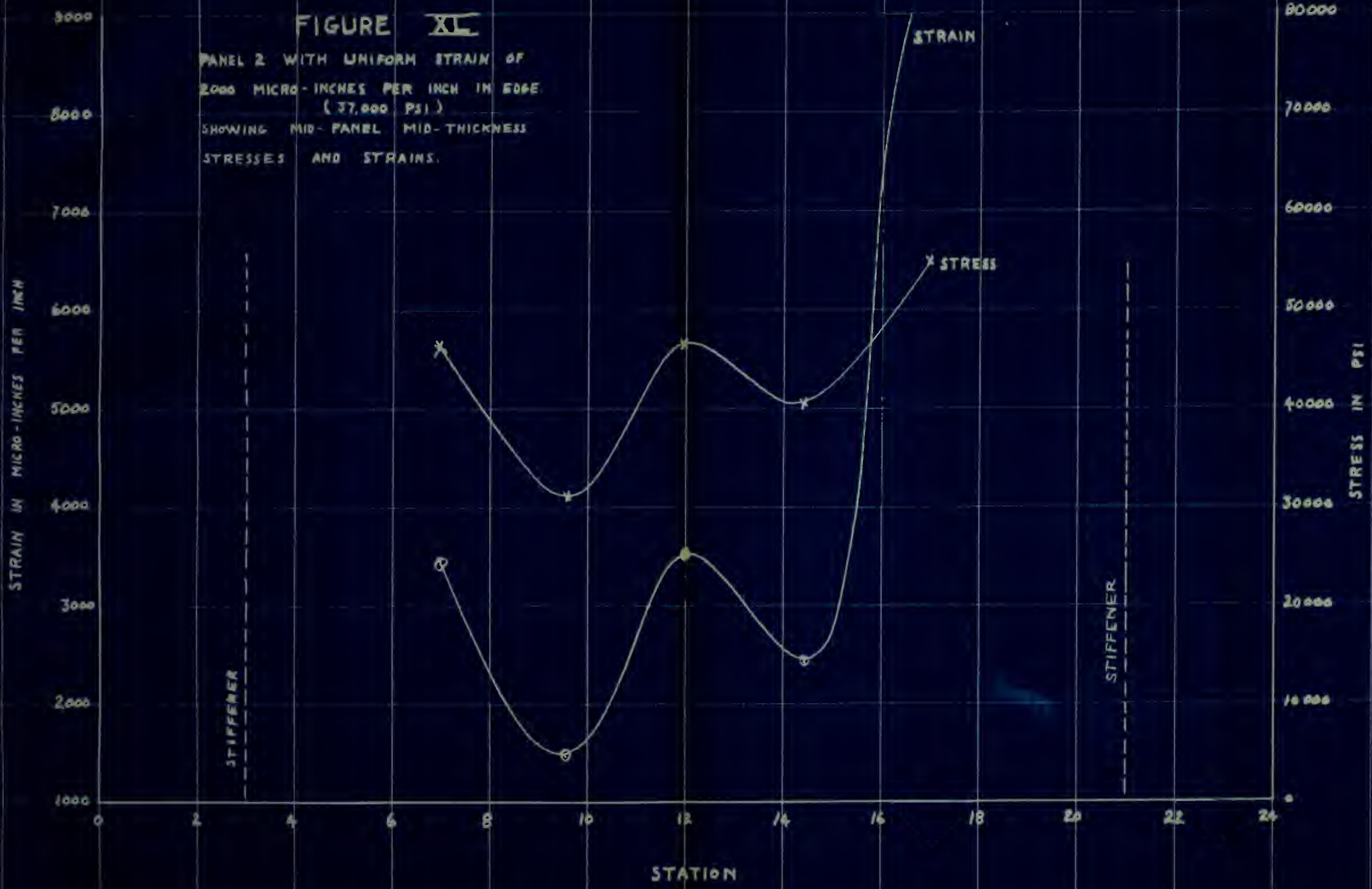


FIGURE XL

PANEL 2 WITH UNIFORM STRAIN OF 2000 MICRO-INCHES PER INCH IN EDGE ( 37,000 PSI ) SHOWING MID-PANEL MID-THICKNESS STRESSES AND STRAINS.

# III RESULTS

The results of this investigation are summarized by the uniform strain curves, Figures XXXIII - XXXVI for Panel 1 and Figures XXXVII - XL for Panel 2.

## 3.1 Results of Test on Panel 1

The curves depicting the lower values of uniform strain (Figures XXXIII and XXXIV) show a fairly uniform strain distribution across the center of the panel. This strain is about 1.5 times the uniform strain at the edge.

At 1500 micro-inches per inch uniform strain (Figure XXXV) the strain distribution across the panel is uniform with the exception of the large strain at station 18. The average strain across the center (excluding the reading at station 18) is about twice the edge strain.

At 2000 micro-inches per inch (Figure XXXVI) the strain at station 18 is again higher than the strain at the other stations. Station 20 is not plotted since the cross-curve did not give a value corresponding to this edge strain.

## 3.2 Results of Test on Panel 2

At 500 micro-inches per inch uniform strain (Figure XXXVII) the center section shows a fairly uniform strain pattern about equal in magnitude to the edge strain.

The strain in the center section corresponding to 1000 micro-inches per inch uniform edge strain shows a decided variation from a

uniform pattern (see Figure XXXVIII). The highest strain is observed closest to the stiffeners where it reaches a value of five times the edge strain.

Figures XXXIX and XL (corresponding to 1500 and 2000 micro-inches per inch strain respectively) show similar strain patterns. The strain is high near the longitudinal stiffener, goes to a minimum, rises at the center, hits another low point, and rises to another high as it approaches the other longitudinal stiffener. The value of the maximum strain point plotted, at station 19, is about four times the 1500 micro-inch per inch uniform edge loading and five times the 2000 micro-inch per inch uniform strain.

# IV DISCUSSION OF RESULTS

There are two points that should be mentioned before embarking on a general discussion of the strain patterns determined corresponding to uniform tensile loading.

## 4.1 Surface Strain Considerations

All of the strain curve drawn represent average, or heart-of-plate, values for the panels concerned. A study of the strain patterns as determined on the panel surfaces themselves is necessary to the understanding of the phenomena which occurred during the tests. The strain gages on the edges of the plate generally showed correspondence for both panels. The strain for both sides increased in proportion to the increasing load and the gages in corresponding positions indicated strains close enough in magnitude to indicate that tension and not bending was the principal condition. In the same fashion the center of plate strain on opposite sides of Panel 1 showed good correspondence. On Panel 1 gages 4 and 22, 5 and 21, and 6 and 20 were in corresponding locations on opposite sides of the panel. At the 120,000 pound load, for example, the ratio of the principal strains at those three locations was 1.27:1, 1.17:1 and 1.17:1 respectively. This indication of a primarily tensile load is evident throughout the test of Panel 1.

However Panel 2 shows a wide difference in strain readings at corresponding locations on opposite sides of the panel in the center section. On Panel 2 gages 10 and 29, 11 and 30, 12 and 31, 13 and 32, and 14 and 33 were located in corresponding locations on opposite sides

of the plate. Reference to Figures XII and XIII will show that these gages were located in the middle section of the span between the longitudinal stiffeners. The strains on the concave side of the panel (gages 10 - 14) reached very high strain values (up to 10,000 micro-inches per inch at 140,000 pounds load) while the gages on the convex side showed compressive strains at first and eventually tensile strains of small magnitude (see Table XVIII). A graphical representation of the situation can be seen on Figure XVIII where these principal strain readings are plotted as crosses on the unstiffened side and triangles on the stiffened side. These extremes of strain, particularly evident on Panel 2 were not considered in the preparation of the uniform strain curves. Therefore we must conclude that strains in excess of those determined for Panel 2 do exist on one surface of the plate. These strains are in the region of the unsupported span between longitudinal stiffeners on the concave side. However the regions of highest strain were determined to be near the longitudinal stiffeners where it was found that the strain readings on both sides of the panel were of the same order of magnitude. We may then regard the cross-sectional area through the plate over which high strains were obtained as being triangular in shape. The two sides of the panel near the longitudinal stiffeners provide two vertices of the triangle and the concave side of the panel in the middle section of the span between longitudinal stiffeners provides the third.

## 4.2 Bowing of Transverse Stiffeners

The bowing of the transverse stiffeners of Panel 1 as described in paragraph 2.7 is believed to have been caused by the action of the pulling members under load. The bowing of the horizontal portion of the pulling

member caused the ends of the test section to move toward one another, thus forcing the transverse stiffeners to bow. During the test of Panel 2 the horizontal portion of the pulling member did not bow as much as on Panel 1 and the resulting bowing of the transverse stiffeners was noticeably less. It is considered that more uniform loading could be obtained by redesign of the pulling members so as to reduce the amount of bowing in the horizontal portion.

## 4.3 Discussion of Uniform Strain Curves

4.3.1 The 500 micro-inch per inch uniform strain curves. (Figures XXXIII and XXXVIII).

At low magnitudes of strain any effect that the distortion of Panel 2 had on the strain pattern is not discernible. Strain patterns for Panels 1 and 2 appear to be about the same, essentially a uniform strain across the center of the panel.

4.3.2 The 1000 micro-inch per inch uniform strain curves. (Figures XXXIV and XXXVIII).

Panel 1 continues to indicate a uniform strain pattern across the center of the plate. The unfairness of Panel 2 appears to have commenced to markedly affect the strain distribution. The plotted strain nearest to stiffener increased to 5000 micro-inches per inch and to 4000 nearest to the other stiffener.

4.3.3 The 1500 micro-inch per inch uniform strain curves. (Figures XXXV and XXXIX).

Figure XXXV still continues to show uniform strain across the

center except for the point at station 18. Reference to Figures XXIV and XVI shows the possibility of an error in obtaining this point. The value of the center of plate point would be greatly altered by a slightly different mean strain curve drawn through the known points. Because of the paucity of points the curve is not known with much accuracy so it was not considered justifiable to alter the previously constructed curve.

The strain pattern of Panel 2 (Figure XXXIV) assumes an extremely interesting shape when compared with the transverse section through the center of the panel (Figure XI). The similarity of the two curves is quite noticeable. The points of minimum strain correspond to the points of maximum deflection, and the highest strains are found adjacent to the longitudinal stiffeners.

4.3.4 The 2000 micro-inch per inch uniform strain curves. (Figures XXXVI and XL).

The uniform strain curve for Panel 1 reaches a high point at station 18. Since a value for station 20 corresponding to this value of edge strain was not available (see Figure XXV), the impression is gained that strain is increasing as it approaches the stiffener at atation 21. It is probable that station 20 would be more in line with the other stations, and thus expose the point at station 18 as being in error, as was indicated in paragraph 4.3

The strain pattern for Panel 2 retains the same shape and similarity to Figure XI as was noted for the 1500 micro-inches per square inch uniform strain curve.

Note the extremely high strain, and correspondingly large stress near the stiffeners while the bulged portion still does not carry its full share of the load.

# V CONCLUSIONS

It is not considered practical for the authors to come to any quantitative conclusions on the basis of the two samples tested. Panel 1 was tested to obtain general information and to help find the most suitable location for gages for future tests. The gage locations for Panel 2 are considered to have given information to more accurately prepare the plots needed for the analysis. The results appear to confirm that strain and stress distribution is related to the plate distortion as was hypothesized at the commencement of this work. This relationship is particularly emphasized by the results of the test of Panel 2. The irregular contour of the panel and the strain picture at high loads which follows that contour lend credence to the hypothesis. It is hoped that future investigations will quantitatively develop the relationships which appear to exist.

# VI RECOMMENDATIONS

The work on this project has only begun if the type of results envisioned are to be achieved. Therefore the following recommendations for future work are suggested:

6.1 A plane sample should be tested with more strain gages located in the center section and along the edge. The results of the test of Panel 1 indicate that symmetry was not present and that bending did occur. In addition more points are needed in order to plot the variation of strain across the plane panel with sufficient accuracy to prepare the cross-curves.

6.2 More samples, with varying degrees of bulge, and eventually varying aspect ratios, should be tested.

6.3 The possibility of modifying the design of the pulling members to obtain a more uniform load condition at the edges should be investigated. The possibilities of using thicker gusset plates and/or a stiffer horizontal member are suggested. It should be realized however, that the basic problem of obtaining uniform tension along the edge of a plate, using a machine which essentially gives a point load source may never be fully solved.

6.4 The use of an overall strain measurement, such as can be obtained by use of a Berry Gage (or similar mechanical strain indicator) is suggested. This reading should be taken over the length of the test section in the longitudinal direction. This strain can then be compared to the strains obtained by the SR-4 gages. The possibility of using these Berry Gage readings to construct the uniform strain curve should be considered.

Berry Gage readings were taken during the test of Panel 2 at stations 3, 12, and 21 between points located on the horizontal portions of the pulling members using a gage length of 14-1/4 inches. The strains determined from these readings were consistently larger than corresponding strains obtained from SR-4 gage readings. It was felt that these inaccuracies were introduced by the strain in the weld metal joining the test section and pulling member so the Berry Gage data was not used.

6.5 The use of strain gages on the flanges and webs of the longitudinal stiffeners is also recommended. Verification of the test data could then be made by integrating the stress curves for both the center and loaded edge portions of the test section. The resulting values of load should correspond and should agree with the load imposed by the testing machine. Such data taken only on the outside of the flanges was insufficient to make this procedure possible for the test of Panel 2.

6.6 The ultimate form of the results is seen as a plot of dimensionless bulge (bulge magnitude divided by plate thickness) versus a stress concentration factor. This factor would be the maximum stress existing in the plate divided by the uniform stress along the edge. A third parameter could conceivably be aspect ratio.

# VII. APPENDIX

# APPENDIX A

## Test Data

## Table I SR-4 Indicator Readings

(Micro inches per inch)

Panel No. 1

|  | Zero Reading |  |  | 20,000 Pounds |  |  |
|---|---|---|---|---|---|---|
| Gage No. | A Axis | B Axis | C Axis | A Axis | B Axis | C Axis |
| 1 | 5900 | 7360 | 6410 | 6005 | 7420 | 6380 |
| 2 | 5970 | 6410 | 7390 | 6250 | 6575 | 7350 |
| 3 | 6220 | 7390 | 8080 | 6380 | 7440 | 8010 |
| 4 | 5950 | 7050 | 8220 | 6320 | 7210 | 8100 |
| 5 | 6220 | 6880 | 7110 | 6620 | 7010 | 7020 |
| 6 | 4990 | 4710 | 6650 | 5430 | 4910 | 6570 |
| 7 | 3780 | 4770 | 5370 | 3990 | 4835 | 5260 |
| 8 | 6280 | 5750 | 5030 | 6370 | 5790 | 5010 |
| 9 | 6580 | 6215 | 6290 | 6800 | 6290 | 6270 |
| 10 | 5200 | 7130 | 6950 | 5460 | 7290 | 6850 |
| 11 | 6900 | 6070 | 7020 | 7150 | 6170 | 6950 |
| 12 | 5920 | 7570 | 7080 | 6000 | 7600 | 7060 |
| 13 | 5110 | 5870 | 6650 | 5280 | 5940 | 6600 |
| 14 | 7080 | 5900 | 5420 | 7350 | 6040 | 5370 |
| 15 | 7000 | 7140 | 7950 | 7400 | 7300 | 7830 |
| 16 | 7090 | 4950 | 4380 | 7340 | 4990 | 4310 |
| 17 | 8315 | 7120 | 5680 | 8410 | 7150 | 5645 |
| 18 | 3440 | 4710 | 5820 | 3600 | 4780 | 5790 |
| 19 | 4300 | 6780 | 7180 | 4480 | 6810 | 7150 |
| 20 | 7460 | 6020 | 5625 | 7660 | 6110 | 5560 |
| 21 | 7650 | 7280 | 4260 | 7800 | 7290 | 4130 |
| 22 | 4430 | 6840 | 6790 | 4670 | 6890 | 6700 |
| 23 | 7280 | 5600 | 5550 | 7430 | 5660 | 5520 |
| 24 | 4840 | 6900 | 6260 | 4930 | 6910 | 6200 |
| 25 | 5780 | 6510 | 4890 | 5870 | 5510 | 4865 |
| 26 | 6600 | 5440 | 4400 | 6900 | 5510 | 4340 |
| 27 | 4125 | 6160 | 6490 | 4200 | 6180 | 6470 |

Table I SR-4 Indicator Readings

(Micro inches per inch)

Panel No. 1

| | 40,000 Pounds | | | 60,000 Pounds | | |
|---|---|---|---|---|---|---|
| Gage No. | A Axis | B Axis | C Axis | A Axis | B Axis | C Axis |
| 1 | 6150 | 7520 | 6350 | 6290 | 7620 | 6300 |
| 2 | 6580 | 6735 | 7280 | 6880 | 6890 | 7190 |
| 3 | 6550 | 7510 | 7980 | 6710 | 7600 | 7970 |
| 4 | 6840 | 7420 | 7920 | 7520 | 7660 | 7600 |
| 5 | 7400 | 7320 | 6890 | 8280 | 7620 | 6490 |
| 6 | 6070 | 5130 | 6340 | 6830 | 5230 | 5950 |
| 7 | 4170 | 4910 | 5200 | 4340 | 4970 | 5140 |
| 8 | 6440 | 5850 | 4990 | 6530 | 5940 | 4980 |
| 9 | 7060 | 6370 | 6220 | 7280 | 6440 | 6170 |
| 10 | 5640 | 5435 | 6760 | 5910 | 7570 | 6670 |
| 11 | 7475 | 6240 | 6805 | 7810 | 6300 | 6690 |
| 12 | 6110 | 7610 | 7040 | 6220 | 7620 | 7020 |
| 13 | 5410 | 5995 | 6580 | 5530 | 6050 | 6560 |
| 14 | 7620 | 6170 | 5280 | 7910 | 6310 | 5200 |
| 15 | 7835 | 7520 | 7695 | 8250 | 7750 | 7570 |
| 16 | 7600 | 4990 | 4210 | 7850 | 5000 | 4120 |
| 17 | 8560 | 7210 | 5610 | 8720 | 7295 | 5570 |
| 18 | 3710 | 4840 | 5770 | 3820 | 4910 | 5750 |
| 19 | 4640 | 6850 | 7160 | 4800 | 6900 | 7180 |
| 20 | 8140 | 6300 | 5430 | 8830 | 6430 | 5030 |
| 21 | 8410 | 7530 | 4020 | 9150 | 7810 | 3630 |
| 22 | 5080 | 7000 | 6550 | 5660 | 7160 | 6250 |
| 23 | 7610 | 5760 | 5550 | 7800 | 5910 | 5610 |
| 24 | 5010 | 6910 | 6170 | 5080 | 6910 | 6150 |
| 25 | 5970 | 5550 | 4840 | 6070 | 5580 | 4810 |
| 26 | 7260 | 5610 | 4200 | 7640 | 5740 | 4080 |
| 27 | 4280 | 6210 | 6460 | 4370 | 6270 | 6450 |

## Table I SR-4 Indicator Readings

(Micro inches per inch)

| Panel No. 1 | | | | | | |
|---|---|---|---|---|---|---|
| | 80,000 Pounds | | | 100,000 Pounds | | |
| Gage No. | A Axis | B Axis | C Axis | A Axis | B Axis | C Axis |
| 1 | 6450 | 7750 | 6270 | 6620 | 7910 | 6220 |
| 2 | 7190 | 7050 | 7120 | 8310 | 7930 | 6740 |
| 3 | 6910 | 7710 | 7970 | 7140 | 7840 | 7850 |
| 4 | 8160 | 7900 | 7460 | 7630 | 8300 | 7650 |
| 5 | 9730 | 8180 | 5720 | 11900 | 8810 | 5010 |
| 6 | 7670 | 5490 | 5550 | 9600 | 6750 | 4620 |
| 7 | 4530 | 5050 | 5110 | 4730 | 5130 | 5080 |
| 8 | 6630 | 6050 | 4950 | 6740 | 6180 | 4950 |
| 9 | 7490 | 6490 | 6120 | 7750 | 6500 | 6060 |
| 10 | 6760 | 7780 | 6410 | 7580 | 8260 | 6160 |
| 11 | 8120 | 6330 | 6600 | 8420 | 6340 | 6520 |
| 12 | 6350 | 7620 | 7000 | 6510 | 7610 | 6870 |
| 13 | 5655 | 6100 | 6540 | 5810 | 6160 | 6530 |
| 14 | 8230 | 6490 | 5110 | 9520 | 7500 | 4690 |
| 15 | 8760 | 8020 | 7450 | 9290 | 8260 | 7380 |
| 16 | 8070 | 5060 | 4070 | 8430 | 5160 | 4070 |
| 17 | 8900 | 7400 | 5530 | 9100 | 7520 | 5490 |
| 18 | 3950 | 4970 | 5750 | 4090 | 5060 | 5735 |
| 19 | 5000 | 6990 | 7250 | 5220 | 7080 | 7320 |
| 20 | 9560 | 6710 | 4710 | 11170 | 7515 | 3900 |
| 21 | 10440 | 8370 | 2880 | A-2900 | 8970 | 2150 |
| 22 | 6170 | 7300 | 6160 | 6490 | 7570 | 6325 |
| 23 | 8050 | 6090 | 5690 | 8350 | 6305 | 5780 |
| 24 | 5150 | 6940 | 6150 | 5240 | 6950 | 6160 |
| 25 | 6200 | 5630 | 4790 | 6360 | 5710 | 4760 |
| 26 | 7950 | 5900 | 4000 | 8210 | 6050 | 3980 |
| 27 | 4490 | 6340 | 6430 | 4610 | 6430 | 6420 |

## Table I SR-4 Indicator Readings

(Micro inches per inch)

Panel No. 1

| Gage No. | 120,000 Pounds A Axis | 120,000 Pounds B Axis | 120,000 Pounds C Axis | 140,000 Pounds A Axis | 140,000 Pounds B Axis | 140,000 Pounds C Axis |
|---|---|---|---|---|---|---|
| 1 | 6840 | 8080 | 6180 | 7160 | 8270 | 6150 |
| 2 | 10410 | 9630 | 6450 | A-3380 | 10790 | 6310 |
| 3 | 7670 | 7970 | 7010 | 8370 | 8160 | 7760 |
| 4 | 10630 | 9430 | 6960 | A-3190 | 10080 | 6590 |
| 5 | A-3570 | 9180 | 4775 | A-5530 | 9830 | 4340 |
| 6 | A-3680 | 7050 | 3120 | A-5030 | 7660 | 7940 |
| 7 | 5090 | 5250 | 4910 | 5870 | 5430 | 4500 |
| 8 | 6910 | 6350 | 4920 | 7160 | 6530 | 4880 |
| 9 | 8130 | 6500 | 6160 | 8900 | 6650 | 6330 |
| 10 | 8790 | 8890 | 5810 | A-2030 | 9630 | 5470 |
| 11 | 8980 | 6530 | 6460 | A-1200 | 7280 | 6370 |
| 12 | 6750 | 7620 | 6920 | 7130 | 7680 | 6850 |
| 13 | 6040 | 6230 | 6510 | 6340 | 6300 | 6470 |
| 14 | 11450 | 8750 | 4170 | A-3810 | 9220 | 3900 |
| 15 | 10160 | 8530 | 7330 | A-2050 | 8930 | 6770 |
| 16 | 10320 | 5480 | 3940 | A-3330 | 6180 | 3570 |
| 17 | 9380 | 7620 | 5440 | 9900 | 7720 | 5220 |
| 18 | 4340 | 5200 | 5630 | 4730 | 5220 | 5550 |
| 19 | 5570 | 7280 | 7410 | 6160 | 6560 | 7420 |
| 20 | A-4920 | 8360 | 2670 | A-6790 | 9230 | 2340 |
| 21 | A-4010 | 9390 | 2000 | A-6020 | 10160 | 1660 |
| 22 | 8180 | 8250 | 6020 | 10600 | 9050 | 5530 |
| 23 | 8730 | 6500 | 5860 | 9090 | 6570 | 5935 |
| 24 | 5430 | 6970 | 6120 | 5780 | 6930 | 6010 |
| 25 | 6600 | 5790 | 4700 | 7050 | 5820 | 4530 |
| 26 | 8770 | 6300 | 4000 | A-0830 | 6560 | 3950 |
| 27 | 4810 | 6530 | 6390 | 5100 | 6580 | 6330 |

## Table II SR-4 Indicator Readings

(Micro inches per inch)

Panel No. 2

| | Zero Readings | | | 20,000 Pounds | | |
|---|---|---|---|---|---|---|
| Gage No. | A Axis | B Axis | C Axis | A Axis | B Axis | C Axis |
| 1 | 7340 | 6700 | 4750 | 7390 | 6740 | 4750 |
| 2 | 6860 | 3330 | 5750 | 6980 | 3420 | 5710 |
| 3 | 6670 | 7200 | 6180 | 6990 | 7370 | 6110 |
| 4 | 6950 | 6700 | 5030 | 7260 | 6830 | 4930 |
| 5 | 5350 | 6060 | 3700 | 5650 | 6110 | 3650 |
| 6 | 8580 | 6630 | 7620 | 8800 | 6650 | 7590 |
| 7 | 7960 | 5240 | 4810 | 8120 | 5280 | 4780 |
| 8 | 7180 | 6770 | 7590 | 7320 | 6780 | 7510 |
| 9 | 5620 | 5270 | 5110 | 5940 | 5400 | 5050 |
| 10 | 8370 | 8010 | 6580 | 8870 | 8230 | 6520 |
| 11 | 6980 | 7000 | 6830 | 7520 | 7220 | 6720 |
| 12 | 7170 | 7280 | 4800 | 7900 | 7610 | 4700 |
| 13 | 6440 | 5560 | 5150 | 7020 | 5850 | 5050 |
| 14 | 8590 | 6190 | 6580 | 9010 | 6340 | 6500 |
| 15 | 7350 | 7420 | 5410 | 7680 | 7470 | 5320 |
| 16 | 5440 | 6770 | 5360 | 5590 | 6780 | 5270 |
| 17 | 7040 | 6790 | 5750 | 7110 | 6780 | 5720 |
| 18 | 7660 | 7900 | 6050 | 7830 | 7920 | 6050 |
| 19 | 8110 | 6530 | 6630 | 8580 | 6790 | 6570 |
| 20 | 6860 | 4960 | 6150 | 6840 | 4990 | 6150 |
| 21 | 4780 | 4720 | 6030 | 4930 | 4860 | 6020 |
| 22 | 5770 | 7180 | 8470 | 4820 | 7320 | 8450 |
| 23 | - | - | - | - | - | - |
| 24 | 6020 | 4690 | 7130 | 6370 | 4830 | 7070 |
| 25 | 5680 | 6230 | 7770 | 5950 | 6260 | 7710 |
| 26 | 5450 | 6330 | 8320 | 5660 | 6330 | 8280 |
| 27 | 5350 | 4450 | 5550 | 5520 | 4460 | 5510 |
| 28 | 5370 | 5350 | 6430 | 5400 | 4350 | 6360 |
| 29 | 4180 | 5810 | 5900 | 4070 | 5700 | 5750 |
| 30 | 4280 | 6490 | 8030 | 4300 | 6490 | 7930 |
| 31 | 4980 | 4950 | 7980 | 4820 | 4780 | 7800 |
| 32 | 7400 | 7110 | 7150 | 4350 | 5980 | 6760 |
| 33 | 4270 | 6000 | 6870 | 4350 | 5980 | 6760 |
| 34 | 4550 | 6800 | 6360 | 4720 | 6850 | 6320 |
| 35 | 3980 | 4860 | 6790 | 4060 | 4840 | 6760 |
| 36 | 5940 | 4300 | 7240 | 6120 | 4420 | 7140 |
| 37 | 6070 | | | 6060 | | |
| 38 | 6320 | | | 6430 | | |
| 39 | 6930 | | | 7360 | | |
| 40 | 6640 | | | 6870 | | |
| 41 | 6680 | | | 6790 | | |
| 42 | 4410 | | | 4610 | | |
| B1 | 0.443" | | | 0.443" | | |
| B2 | 0.415" | | | 0.403" | | |
| B3 | 0.344" | | | 0.343" | | |

## Table II SR-4 Indicator Readings

(Micro inches per inch)

Panel No. 2

| | 40,000 Pounds | | | 60,000 Pounds | | |
|---|---|---|---|---|---|---|
| Gage No. | A Axis | B Axis | C Axis | A Axis | B Axis | C Axis |
| 1 | 7530 | 6830 | 4740 | 7680 | 6910 | 4740 |
| 2 | 7160 | 3540 | 5660 | 7360 | 3640 | 5620 |
| 3 | 7380 | 7530 | 6040 | 7800 | 7700 | 6000 |
| 4 | 7680 | 7050 | 4840 | 8140 | 7310 | 4760 |
| 5 | 5960 | 6190 | 3590 | 6280 | 6250 | 3510 |
| 6 | 9030 | 6720 | 7560 | 9250 | 6790 | 7550 |
| 7 | 8280 | 5330 | 4760 | 8440 | 5380 | 4740 |
| 8 | 7520 | 6810 | 7400 | 7740 | 6860 | 7280 |
| 9 | 6320 | 6570 | 4990 | 6720 | 5720 | 4910 |
| 10 | 9420 | 8490 | 6460 | 10000 | 8750 | 6380 |
| 11 | 8030 | 7450 | 6590 | 8540 | 7670 | 6450 |
| 12 | 8610 | 7950 | 4610 | 9600 | 8430 | 4540 |
| 13 | 7610 | 6130 | 4970 | 8490 | 6640 | 4910 |
| 14 | 9440 | 6480 | 6400 | 9690 | 6580 | 6310 |
| 15 | 7900 | 7550 | 5220 | 8690 | 7780 | 5060 |
| 16 | 5800 | 6820 | 5150 | 6110 | 6890 | 5050 |
| 17 | 7210 | 6790 | 5710 | 7330 | 6810 | 5680 |
| 18 | 8060 | 7980 | 6050 | 8330 | 8060 | 6050 |
| 19 | 9510 | 7290 | 6540 | A-1390 | 7690 | 6410 |
| 20 | 6940 | 5070 | 6160 | 7120 | 5180 | 6120 |
| 21 | 5130 | 5010 | 6010 | 5330 | 5150 | 6010 |
| 22 | 6080 | 7440 | 8410 | 6270 | 7540 | 8370 |
| 23 | - | - | - | - | - | - |
| 24 | 6750 | 5060 | 7010 | 7100 | 5290 | 6970 |
| 25 | 6180 | 6280 | 7630 | 6390 | 6280 | 7530 |
| 26 | 5820 | 6350 | 8240 | 5980 | 6380 | 8200 |
| 27 | 5710 | 4500 | 5490 | 5880 | 4550 | 5480 |
| 28 | 5440 | 5350 | 6280 | 5500 | 5350 | 6200 |
| 29 | 4000 | 5600 | 5890 | 3960 | 5490 | 5420 |
| 30 | 4400 | 6500 | 7810 | 4560 | 6560 | 7720 |
| 31 | 4740 | 4690 | 7640 | 4660 | 4580 | 7480 |
| 32 | 7180 | 6740 | 7820 | 7100 | 6480 | 7610 |
| 33 | 4490 | 5960 | 6630 | 4800 | 6000 | 6460 |
| 34 | 4930 | 6930 | 6260 | 5620 | 7350 | 6150 |
| 35 | 4160 | 4840 | 6720 | 4270 | 4840 | 6680 |
| 36 | 6280 | 4540 | 7080 | 6640 | 4650 | 6920 |
| 37 | 6000 | | | 5940 | | |
| 38 | 6350 | | | 6220 | | |
| 39 | 7460 | | | 7460 | | |
| 40 | 6850 | | | 6780 | | |
| 41 | 6730 | | | 6630 | | |
| 42 | 4690 | | | 4670 | | |
| B1 | 0.425" | | | 0.396" | | |
| B2 | 0.367" | | | 0.320" | | |
| B3 | 0.324" | | | 0.288" | | |

## Table II SR-4 Indicator Readings

(Micro inches per inch)

| Panel No. 2 | | | | | | |
|---|---|---|---|---|---|---|
| | 80,000 Pounds | | | 100,000 Pounds | | |
| Gage No. | A Axis | B Axis | C Axis | A Axis | B Axis | C Axis |
| 1 | 7850 | 7000 | 4720 | 8040 | 7080 | 4720 |
| 2 | 7570 | 3740 | 5590 | 7750 | 3840 | 5580 |
| 3 | 8540 | 7950 | 5940 | 10110 | 5820 | 8480 |
| 4 | 8680 | 7670 | 4680 | 9250 | 8070 | 4620 |
| 5 | 6710 | 6280 | 3360 | 7400 | 6340 | 3120 |
| 6 | 9440 | 6860 | 6580 | 9630 | 6910 | 7610 |
| 7 | 8600 | 5430 | 4730 | 8790 | 5480 | 4710 |
| 8 | 8030 | 6920 | 7150 | 8430 | 7000 | 6970 |
| 9 | 7690 | 6180 | 4810 | 9160 | 6860 | 4710 |
| 10 | A-1790 | 9400 | 6310 | A-3460 | 10200 | 6320 |
| 11 | 9050 | 7880 | 6230 | 9430 | 8000 | 5890 |
| 12 | A-2180 | 9330 | 4480 | A-4680 | 10470 | 4370 |
| 13 | 9630 | 7270 | 4850 | A-1330 | 7910 | 4780 |
| 14 | 10270 | 6710 | 6190 | A-3110 | 7330 | 5840 |
| 15 | 10570 | 8190 | 4860 | A-2550 | 8750 | 4680 |
| 16 | 6600 | 7040 | 4920 | 7160 | 7180 | 4740 |
| 17 | 7470 | 6840 | 5650 | 7600 | 6850 | 5620 |
| 18 | 8600 | 8140 | 6060 | 8850 | 8200 | 6090 |
| 19 | A-3180 | 8580 | 6130 | A-5200 | 9780 | 5840 |
| 20 | 7320 | 5320 | 6100 | 7530 | 5460 | 6090 |
| 21 | 5540 | 5280 | 6010 | 5730 | 5410 | 6040 |
| 22 | 6460 | 7630 | 8340 | 6620 | 7700 | 8340 |
| 23 | - | - | - | - | - | - |
| 24 | 7410 | 5560 | 6940 | 7660 | 5850 | 6950 |
| 25 | 6590 | 6210 | 7370 | 6910 | 6090 | 7110 |
| 26 | 6100 | 6420 | 8180 | 6210 | 6460 | 8180 |
| 27 | 6010 | 4580 | 5500 | 6130 | 4590 | 5540 |
| 28 | 5530 | 5380 | 6120 | 5680 | 5420 | 5930 |
| 29 | 3820 | 5310 | 5210 | 3870 | 5250 | 4900 |
| 30 | 4750 | 6680 | 7690 | 5160 | 6910 | 7680 |
| 31 | 4670 | 4460 | 7220 | 5160 | 4560 | 6920 |
| 32 | 7120 | 6180 | 7380 | 7400 | 5970 | 7160 |
| 33 | 5500 | 6280 | 6270 | 7690 | 7230 | 5940 |
| 34 | 7450 | 8450 | 6060 | 9080 | 9450 | 5980 |
| 35 | 4380 | 4850 | 6650 | 4470 | 4830 | 6620 |
| 36 | 7380 | 4760 | 6630 | 8360 | 5010 | 6210 |
| 37 | 5910 | | | 5920 | | |
| 38 | 6080 | | | 6030 | | |
| 39 | 7450 | | | 7570 | | |
| 40 | 6730 | | | 6750 | | |
| 41 | 6510 | | | 6490 | | |
| 42 | 4650 | | | 4750 | | |
| B1 | 0.359" | | | 0.335" | | |
| B2 | 0.265" | | | 0.216" | | |
| B3 | 0.249" | | | 0.216" | | |

## Table II SR-4 Indicator Readings

(Micro inches per inch)

| Panel No. 2 | | | | | | |
|---|---|---|---|---|---|---|
| | 120,000 Pounds | | | 140,000 Pounds | | |
| Gage No. | A Axis | B Axis | C Axis | A Axis | B Axis | C Axis |
| 1 | 8260 | 7200 | 4720 | 8500 | 7330 | 4720 |
| 2 | 7990 | 3930 | 5550 | 8190 | 3960 | 5460 |
| 3 | A-2680 | 9950 | 5380 | A-4980 | 11800 | A-950 |
| 4 | 10180 | 8600 | 4510 | A-2870 | 9540 | 3950 |
| 5 | 8830 | 6870 | 3040 | 10600 | 7610 | 2780 |
| 6 | 9910 | 7020 | 7640 | 10120 | 7150 | 7680 |
| 7 | 9030 | 5510 | 4650 | 9370 | 5710 | 4530 |
| 8 | 8920 | 7070 | 6180 | 9520 | 7150 | 6570 |
| 9 | A-1320 | 7560 | 4590 | A-2500 | 8040 | 4490 |
| 10 | A-5000 | 10780 | 6370 | A-6170 | A-1870 | 6400 |
| 11 | 9990 | 8320 | 5510 | A-2100 | 9190 | 4910 |
| 12 | A-8160 | A-2520 | 4050 | | A-3820 | 3250 |
| 13 | A-2450 | 8440 | 4780 | A-4470 | 9280 | 4810 |
| 14 | A-7120 | 9080 | 5140 | A-9930 | 9980 | 4690 |
| 15 | A-3940 | 9450 | 4490 | A-5360 | 9980 | 4300 |
| 16 | 7790 | 7320 | 4520 | 8390 | 7430 | 4250 |
| 17 | 7780 | 6860 | 5570 | 8040 | 6890 | 5500 |
| 18 | 9140 | 8270 | 6130 | 9490 | 8390 | 6190 |
| 19 | A-6860 | A-0300 | 5450 | A-8720 | 10310 | 4960 |
| 20 | 7790 | 5630 | 6060 | 8130 | 5820 | 5990 |
| 21 | 5950 | 5580 | 6140 | 6200 | 5790 | 6260 |
| 22 | 6830 | 7690 | 8280 | 7490 | 7790 | 8070 |
| 23 | - | - | - | - | - | - |
| 24 | 8110 | 6190 | 6890 | 9780 | 6760 | 6410 |
| 25 | 7750 | 6150 | 6950 | 9030 | 6410 | 6750 |
| 26 | 6420 | 6490 | 8160 | 6940 | 6510 | 8070 |
| 27 | 6290 | 4630 | 5590 | 6450 | 4670 | 5610 |
| 28 | 6100 | 5470 | 5690 | 7080 | 5670 | 5440 |
| 29 | 4330 | 5470 | 4650 | 5470 | 6000 | 4420 |
| 30 | 6320 | 7380 | 7610 | 9270 | 8650 | 7630 |
| 31 | 6620 | 5220 | 6370 | 10570 | 7290 | 5870 |
| 32 | 8040 | 6050 | 7100 | 9930 | 6560 | 6850 |
| 33 | A-2030 | 8930 | 5400 | A-4830 | 9860 | 5020 |
| 34 | 10610 | 10150 | 5890 | A-2500 | 10510 | 5740 |
| 35 | 4540 | 4780 | 6600 | 4600 | 4690 | 6580 |
| 36 | 9350 | 5350 | 5830 | 10580 | 5730 | 5410 |
| 37 | 5980 | | | 6080 | | |
| 38 | 6020 | | | 6080 | | |
| 39 | 7770 | | | 8020 | | |
| 40 | 6850 | | | 7040 | | |
| 41 | 6520 | | | 6610 | | |
| 42 | 4920 | | | 5220 | | |
| B1 | 0.294" | | | 0.244" | | |
| B2 | 0.140" | | | 0.043" | | |
| B3 | 0.171" | | | 0.122" | | |

# APPENDIX B

## Calculations of Principal Strains

## TABLE III
## Calculation of Principal Strains

Panel No. 1 Load 20,000 pounds

| | A | B | C | D | E |
|---|---|---|---|---|---|
| Gage No. | A axis strain | B axis strain | C axis strain | | |
| | | | | ½(A+B) | A-D |
| 1 | 0105 | 0060 | -0030 | 37.5 | 67.5 |
| 2 | 0280 | 0165 | -0040 | 120 | 160 |
| 3 | 0160 | 0050 | -0070 | 45 | 115 |
| 4 | 0370 | 0160 | -0120 | 125 | 245 |
| 5 | 0400 | 0130 | -0090 | 155 | 245 |
| 6 | 0440 | 0200 | -0080 | 180 | 260 |
| 7 | 0210 | 0065 | -0110 | 50 | 160 |
| 8 | 0090 | 0040 | -0020 | 35 | 55 |
| 9 | 0220 | 0075 | -0020 | 100 | 120 |
| 10 | 0260 | 0160 | -0100 | 80 | 180 |
| 11 | 0250 | 0100 | -0070 | 90 | 160 |
| 12 | 0080 | 0030 | -0020 | 30 | 50 |
| 13 | 0170 | 0070 | -0050 | 60 | 110 |
| 14 | 0270 | 0140 | -0050 | 110 | 160 |
| 15 | 0400 | 0160 | -0120 | 140 | 260 |
| 16 | 0250 | 0040 | -0070 | 90 | 160 |
| 17 | 0095 | 0030 | -0035 | 30 | 65 |
| 18 | 0160 | 0070 | -0030 | 65 | 95 |
| 19 | 0180 | 0030 | -0030 | 75 | 105 |
| 20 | 0200 | 0090 | -0065 | 67.5 | 132.5 |
| 21 | 0150 | 0010 | -0130 | 10 | 140 |
| 22 | 0240 | 0050 | -0090 | 75 | 165 |
| 23 | 0150 | 0060 | -0030 | 60 | 90 |
| 24 | 0090 | 0010 | -0060 | 15 | 75 |
| 25 | 0090 | 0000 | -0025 | 32.5 | 57.5 |
| 26 | 0300 | 0070 | -0060 | 120 | 180 |
| 27 | 0075 | 0020 | -0020 | 27.5 | 47.5 |

### TABLE III (continued)
### Calculation of Principal Strains

Panel No. 1 Load 20,000 pounds

| | F | G | H | I | J | K |
|---|---|---|---|---|---|---|
| | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| Gage No. | B-D | $(E^2 F^2)^{\frac{1}{2}}$ | Arc Tan F/E | ½ H | D+G | D-G |
| 1 | 22.5 | 71.4 | 18.4 | 9.2 | 109 | -34 |
| 2 | 45 | 166 | 15.7 | 7.8 | 286 | -46 |
| 3 | 5 | 115 | 2.5 | 1.2 | 160 | -70 |
| 4 | 35 | 248 | 8.1 | 4.0 | 373 | -123 |
| 5 | -25 | 245 | -6.0 | -3.0 | 400 | -90 |
| 6 | 20 | 260 | 4.4 | 2.2 | 440 | -80 |
| 7 | 15 | 160 | 5.4 | 2.7 | 210 | -110 |
| 8 | 5 | 55 | 5.2 | 2.6 | 90 | -20 |
| 9 | -25 | 123 | -11.75 | -5.9 | 223 | -23 |
| 10 | 80 | 197 | 23.9 | 12 | 277 | -117 |
| 11 | 10 | 160 | 0.9 | .4 | 250 | -70 |
| 12 | 0 | 50 | 0 | 0 | 80 | -20 |
| 13 | 10 | 110 | 5.2 | 2.6 | 170 | -50 |
| 14 | 30 | 163 | 10.6 | 5.3 | 273 | -53 |
| 15 | 20 | 268 | 4.4 | 2.2 | 400 | -120 |
| 16 | -50 | 168 | -17.3 | -8.6 | 258 | -78 |
| 17 | 0 | 65 | 0 | 0 | 85 | -35 |
| 18 | 5 | 95 | 3.0 | 1.5 | 160 | -30 |
| 19 | -45 | 113 | -23.4 | -11.7 | 188 | -38 |
| 20 | 22.5 | 135 | 9.62 | 4.8 | 203 | -67 |
| 21 | 0 | 140 | 0 | 0 | 150 | -130 |
| 22 | -25 | 167 | -8.6 | -4.3 | 242 | -92 |
| 23 | 0 | 90 | 0 | 0 | 150 | -30 |
| 24 | -5 | 75 | -3.8 | -1.9 | 90 | -60 |
| 25 | -32.5 | 66.3 | -29.4 | -147 | 99 | -34 |
| 26 | -50 | 18.7 | -15.5 | -7.8 | 307 | -67 |
| 27 | -7.5 | 48.2 | -8.95 | -4.5 | 76 | -20 |

# TABLE IV
## Calculation of Principal Strains

Panel No. 1 Load 40,000 pounds

| | A | B | C | D | E |
|---|---|---|---|---|---|
| Gage No. | A Axis strain | B Axis strain | C Axis strain | | |
| | | | | ½ (A+B) | A-D |
| 1 | 0250 | 0160 | -0060 | 95 | 155 |
| 2 | 0610 | 0325 | -0110 | 250 | 360 |
| 3 | 0330 | 0120 | -0100 | 115 | 215 |
| 4 | 0890 | 0370 | -0300 | 295 | 595 |
| 5 | 1180 | 0440 | -0220 | 480 | 700 |
| 6 | 1080 | 0420 | -0310 | 385 | 695 |
| 7 | 0390 | 0140 | -0170 | 110 | 280 |
| 8 | 0160 | 0100 | -0040 | 60 | 100 |
| 9 | 0480 | 0155 | -0070 | 205 | 275 |
| 10 | 0440 | 0305 | -0190 | 125 | 315 |
| 11 | 0575 | 0170 | -0215 | 180 | 395 |
| 12 | 0190 | 0040 | -0040 | 75 | 115 |
| 13 | 0300 | 0125 | -0070 | 115 | 185 |
| 14 | 0540 | 0270 | -0140 | 200 | 340 |
| 15 | 0835 | 0380 | -0255 | 290 | 545 |
| 16 | 0510 | 0040 | -0170 | 170 | 340 |
| 17 | 0245 | 0090 | -0070 | 88 | 157 |
| 18 | 0270 | 0130 | -0050 | 110 | 160 |
| 19 | 0340 | 0070 | -0020 | 160 | 180 |
| 20 | 0680 | 0280 | -0195 | 242 | 438 |
| 21 | 0760 | 0250 | -0240 | 260 | 500 |
| 22 | 0650 | 0160 | -0240 | 205 | 445 |
| 23 | 0330 | 0160 | -0000 | 165 | 165 |
| 24 | 0170 | 0010 | -0090 | 40 | 130 |
| 25 | 0190 | 0040 | -0050 | 70 | 120 |
| 26 | 0660 | 0170 | -0200 | 230 | 430 |
| 27 | 0155 | 0050 | -0030 | 62 | 93 |

## TABLE IV (continued)
## Calculation of Principal Strains

| Panel No. 1 Load 40,000 pounds | | | | | | |
|---|---|---|---|---|---|---|
| | F | G | H | I | J | K |
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B-D | $(E^2 F^2)^{\frac{1}{2}}$ | Arc Tan F/E | $\frac{1}{2}$ H | D+G | D-G |
| 1 | 65 | 167 | 22.7 | 11.4 | 262 | -72 |
| 2 | 75 | 368 | 11.8 | 5.9 | 618 | -118 |
| 3 | 5 | 215 | 1.3 | 0.7 | 330 | -100 |
| 4 | 75 | 600 | 7.2 | 3.6 | 895 | -305 |
| 5 | -40 | 700 | -3.3 | -1.6 | 1180 | -220 |
| 6 | 35 | 695 | 2.9 | 1.0 | 1080 | -310 |
| 7 | 30 | 282 | 6.1 | 3.0 | 392 | -172 |
| 8 | 40 | 108 | 21.8 | 10.9 | 168 | -48 |
| 9 | -50 | 280 | -10.3 | -5.6 | 485 | -75 |
| 10 | 180 | 363 | 29.7 | 14.8 | 488 | -238 |
| 11 | -10 | 395 | -1.5 | -0.8 | 575 | -215 |
| 12 | -35 | 120 | -16.9 | -8.4 | 195 | -45 |
| 13 | 10 | 186 | 5.7 | 2.8 | 301 | -71 |
| 14 | 70 | 348 | 11.6 | 5.8 | 548 | -148 |
| 15 | 90 | 553 | 9.4 | 4.7 | 843 | -263 |
| 16 | -130 | 364 | -20.9 | -10.4 | 534 | -194 |
| 17 | 2 | 157 | 1.5 | 0.8 | 245 | -69 |
| 18 | 20 | 161 | 7.1 | 3.6 | 271 | -51 |
| 19 | -90 | 202 | -26.5 | -13.2 | 362 | -42 |
| 20 | 38 | 438 | 5.0 | 2.5 | 680 | -196 |
| 21 | -10 | 500 | -10.2 | -5.1 | 760 | -240 |
| 22 | -45 | 449 | -5.8 | -2.9 | 654 | -244 |
| 23 | -5 | 165 | -1.7 | -0.8 | 330 | 0 |
| 24 | -30 | 133 | -13.0 | -6.5 | 173 | -93 |
| 25 | -30 | 124 | -14.0 | -7.0 | 194 | -54 |
| 26 | -60 | 435 | -7.9 | -4.0 | 665 | -205 |
| 27 | -12 | 94 | -7.4 | -3.7 | 156 | -32 |

## TABLE V
## Calculation of Principal Strains

Panel No. 1 Load 60,000 pounds

| | A | B | C | D | E |
|---|---|---|---|---|---|
| Gage No. | A axis strain | B axis strain | C axis strain | | |
| | | | | ½ (A+B) | A-D |
| 1 | 0390 | 0260 | -0110 | 140 | 250 |
| 2 | 0910 | 0480 | -0200 | 355 | 555 |
| 3 | 0490 | 0210 | -0110 | 140 | 350 |
| 4 | 1570 | 0510 | -0620 | 475 | 1095 |
| 5 | 2060 | 0740 | -0620 | 720 | 1340 |
| 6 | 1840 | 0520 | -0700 | 570 | 1270 |
| 7 | 0560 | 0200 | -0230 | 165 | 395 |
| 8 | 0250 | 0190 | -0050 | 100 | 150 |
| 9 | 0700 | 0225 | -0120 | 290 | 410 |
| 10 | 0710 | 0440 | -0280 | 215 | 495 |
| 11 | 0910 | 0230 | -0330 | 290 | 620 |
| 12 | 0300 | 0050 | -0060 | 120 | 180 |
| 13 | 0420 | 0180 | -0090 | 165 | 255 |
| 14 | 0830 | 0410 | -0220 | 305 | 525 |
| 15 | 1250 | 0610 | -0380 | 435 | 815 |
| 16 | 0760 | 0050 | -0260 | 250 | 510 |
| 17 | 0405 | 0175 | -0110 | 148 | 257 |
| 18 | 0380 | 0200 | -0070 | 155 | 225 |
| 19 | 0500 | 0120 | -0000 | 250 | 250 |
| 20 | 1370 | 0410 | -0595 | 388 | 982 |
| 21 | 1500 | 0530 | -0630 | 435 | 1065 |
| 22 | 1230 | 0320 | -0540 | 345 | 885 |
| 23 | 0520 | 0310 | 0060 | 290 | 230 |
| 24 | 0240 | 0010 | -0110 | 65 | 175 |
| 25 | 0290 | 0070 | -0080 | 105 | 185 |
| 26 | 1040 | 0300 | -0320 | 360 | 680 |
| 27 | 0245 | 0110 | -0040 | 102 | 143 |

## TABLE V (continued)
## Calculation of Principal Strains

Panel No. 1 Load 60,000 pounds

| | F | G | H | I | J | K |
|---|---|---|---|---|---|---|
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B-D | $(E^2 F^2)^{\frac{1}{2}}$ | Arc Tan F/E | ½ H | D+G | D-G |
| 1 | -120 | 278 | -25.6 | -12.8 | 418 | -138 |
| 2 | 125 | 569 | 12.7 | 6.4 | 924 | -214 |
| 3 | 70 | 357 | 11.3 | 5.6 | 497 | -217 |
| 4 | 35 | 1095 | 1.8 | .9 | 1570 | -620 |
| 5 | 20 | 1340 | .9 | .4 | 2060 | -620 |
| 6 | -50 | 1270 | -2.3 | -1.2 | 1840 | -700 |
| 7 | 35 | 395 | 5.1 | 2.6 | 560 | -230 |
| 8 | 90 | 175 | 30.9 | 15.4 | 275 | -75 |
| 9 | -65 | 415 | -9.0 | -4.5 | 705 | -125 |
| 10 | 225 | 545 | 24.4 | 12.2 | 760 | -330 |
| 11 | -60 | 620 | -5.6 | -2.8 | 910 | -330 |
| 12 | -70 | 194 | -21.2 | -10.6 | 314 | -74 |
| 13 | 15 | 255 | 3.4 | 1.7 | 420 | -90 |
| 14 | 105 | 536 | 11.3 | 5.6 | 841 | -231 |
| 15 | 175 | 835 | 12.1 | 6.0 | 1270 | -400 |
| 16 | -200 | 548 | -21.4 | -10.7 | 798 | -298 |
| 17 | 27 | 258 | 6.0 | 3.0 | 406 | -110 |
| 18 | 45 | 230 | 11.3 | 5.6 | 385 | -75 |
| 19 | -130 | 282 | -27.4 | -13.7 | 532 | -32 |
| 20 | 22 | 982 | 1.3 | .6 | 1370 | -594 |
| 21 | 95 | 1065 | 5.1 | 2.6 | 1500 | -630 |
| 22 | -25 | 885 | -1.6 | -.8 | 1230 | -540 |
| 23 | 20 | 230 | 5.0 | 2.5 | 520 | 60 |
| 24 | -55 | 184 | -17.4 | -8.7 | 249 | -119 |
| 25 | -35 | 189 | -10.7 | -5.4 | 294 | -84 |
| 26 | -60 | 680 | -5.1 | -2.6 | 1040 | -320 |
| 27 | 8 | 143 | 3.2 | 1.6 | 245 | -41 |

# TABLE VI
## Calculation of Principal Strains

| Panel No. 1 Load 80,000 pounds | | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Gage No. | A axis strain | B axis strain | C axis strain | | |
| | | | | ½ (A+B) | A-D |
| 1 | 0550 | 0390 | -0140 | 205 | 345 |
| 2 | 1220 | 0640 | -0270 | 475 | 745 |
| 3 | 0690 | 0320 | -0110 | 290 | 400 |
| 4 | 2210 | 0850 | -0760 | 725 | 1485 |
| 5 | 3510 | 1300 | -1390 | 1060 | 2450 |
| 6 | 2680 | 0780 | -1100 | 790 | 1890 |
| 7 | 0750 | 0280 | -0260 | 245 | 505 |
| 8 | 0350 | 0300 | -0080 | 135 | 215 |
| 9 | 0910 | 0275 | -0170 | 370 | 540 |
| 10 | 1560 | 0650 | -0540 | 510 | 1050 |
| 11 | 1220 | 0260 | -0420 | 400 | 820 |
| 12 | 0430 | 0050 | -0080 | 175 | 255 |
| 13 | 0545 | 0230 | -0110 | 218 | 327 |
| 14 | 1150 | 0590 | -0310 | 420 | 730 |
| 15 | 1760 | 0880 | -0500 | 630 | 1130 |
| 16 | 0980 | 0110 | -0310 | 335 | 645 |
| 17 | 0585 | 0280 | -0150 | 218 | 367 |
| 18 | 0510 | 0260 | -0070 | 220 | 290 |
| 19 | 0700 | 0210 | 0070 | 315 | 385 |
| 20 | 2100 | 0690 | -0915 | 598 | 1502 |
| 21 | 2790 | 1090 | -1380 | 705 | 2085 |
| 22 | 1740 | 0460 | -0630 | 555 | 1185 |
| 23 | 0770 | 0490 | 0140 | 315 | 455 |
| 24 | 0310 | 0040 | -0110 | 100 | 210 |
| 25 | 0420 | 0120 | -0100 | 160 | 260 |
| 26 | 1350 | 0460 | -0400 | 475 | 875 |
| 27 | 0365 | 0180 | -0060 | 152 | 213 |

## TABLE VI (continued)
## Calculation of Principal Strains

| Panel No. 1 Load 80,000 pounds | | | | | | |
|---|---|---|---|---|---|---|
| | F | G | H | I | J | K |
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B-D | $(E^2 F^2)^{\frac{1}{2}}$ | Arc Tan F/E | $\frac{1}{2}$ H | D+G | D-G |
| 1 | 185 | 392 | 28.2 | 14.1 | 737 | -47 |
| 2 | 165 | 763 | 12.5 | 6.3 | 1238 | -288 |
| 3 | 30 | 400 | 4.3 | 2.2 | 610 | -110 |
| 4 | 125 | 1485 | 4.9 | 2.4 | 2210 | -760 |
| 5 | 240 | 2450 | 5.6 | 2.8 | 3510 | -1390 |
| 6 | -10 | 1890 | 0 | 0 | 2680 | -1100 |
| 7 | 35 | 505 | 4.0 | 2.0 | 750 | -260 |
| 8 | 165 | 271 | 37.5 | 18.8 | 406 | -136 |
| 9 | -95 | 546 | -10.0 | -5.0 | 9116 | -176 |
| 10 | 140 | 1060 | 7.6 | 3.8 | 1570 | -550 |
| 11 | -140 | 834 | -9.7 | -4.8 | 1234 | -434 |
| 12 | -125 | 284 | -26.2 | -13.1 | 459 | -109 |
| 13 | 12 | 327 | 2.1 | 1.0 | 545 | -109 |
| 14 | 170 | 751 | 13.1 | 6.6 | 1171 | -331 |
| 15 | 250 | 1160 | 12.5 | 6.2 | 1790 | -530 |
| 16 | -225 | 684 | -19.2 | -9.6 | 1019 | -349 |
| 17 | 62 | 372 | 9.6 | 4.8 | 590 | -154 |
| 18 | 40 | 294 | 7.8 | 3.9 | 514 | -74 |
| 19 | -105 | 399 | -15.2 | -7.6 | 714 | 84 |
| 20 | 92 | 1502 | 3.5 | 1.8 | 2100 | -904 |
| 21 | 385 | 2120 | 10.4 | 5.2 | 2825 | -1415 |
| 22 | -95 | 1185 | -4.6 | -2.3 | 1740 | -630 |
| 23 | 175 | 488 | 21.0 | 10.5 | 803 | -173 |
| 24 | -60 | 219 | -15.9 | -8.0 | 319 | -119 |
| 25 | -40 | 263 | -8.8 | -4.4 | 423 | -103 |
| 26 | -15 | 875 | -1.0 | -0.5 | 1350 | -400 |
| 27 | 28 | 215 | 7.5 | 3.8 | 367 | -63 |

## TABLE VII
## Calculation of Principal Strains

| Panel No. 1 Load 100,000 pounds | | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Gage No. | A axis strain | B axis strain | C axis strain | | |
| | | | | ½ (A+B) | A-D |
| 1 | 0720 | 0550 | -0190 | 265 | 455 |
| 2 | 2340 | 1520 | -0650 | 845 | 1495 |
| 3 | 0920 | 0450 | -0130 | 395 | 525 |
| 4 | 2680 | 1250 | -0570 | 1055 | 2150 |
| 5 | 5680 | 1930 | -2100 | 1790 | 3890 |
| 6 | 4610 | 1540 | -2030 | 1290 | 3320 |
| 7 | 0150 | 0360 | -0290 | 330 | 620 |
| 8 | 0460 | 0430 | -0080 | 190 | 270 |
| 9 | 1170 | 0285 | -0230 | 470 | 700 |
| 10 | 2580 | 1130 | -0790 | 895 | 1685 |
| 11 | 1520 | 0270 | -0500 | 510 | 1010 |
| 12 | 0590 | 0040 | -0110 | 240 | 350 |
| 13 | 0700 | 0290 | -0120 | 290 | 410 |
| 14 | 2440 | 1600 | -0730 | 855 | 1585 |
| 15 | 2290 | 1120 | -0570 | 585 | 1705 |
| 16 | 1340 | 0210 | -0310 | 515 | 825 |
| 17 | 0785 | 0400 | -0190 | 298 | 487 |
| 18 | 0650 | 0350 | -0085 | 282 | 368 |
| 19 | 0920 | 0300 | 0140 | 530 | 390 |
| 20 | 3710 | 1495 | -1725 | 992 | 2720 |
| 21 | 4710 | 1690 | -2110 | 1300 | 3410 |
| 22 | 2060 | 0730 | -0465 | 798 | 1262 |
| 23 | 1070 | 0705 | 0230 | 650 | 420 |
| 24 | 0400 | 0050 | -0100 | 150 | 250 |
| 25 | 0580 | 0200 | -0130 | 225 | 355 |
| 26 | 1610 | 0610 | -0420 | 595 | 1015 |
| 27 | 0485 | 0270 | -0070 | 208 | 277 |

## TABLE VII (Continued)
## Calculation of Principal Strains

Panel No. 1 Load 100,000 pounds

| | F | G | H | I | J | K |
|---|---|---|---|---|---|---|
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B-D | $(E^2\ F^2)^{\frac{1}{2}}$ | Arc Tan F/E | ½ H | D+G | D-G |
| 1 | 285 | 538 | 32.0 | 16.0 | 803 | -273 |
| 2 | 675 | 1640 | 24.3 | 12.2 | 2485 | -795 |
| 3 | 55 | 529 | 5.96 | 3.0 | 924 | -134 |
| 4 | 195 | 2150 | 5.2 | 2.6 | 3205 | -1095 |
| 5 | 140 | 3890 | 2.1 | 1.0 | 5680 | -2100 |
| 6 | 250 | 3320 | 4.3 | 2.2 | 4610 | -2030 |
| 7 | 30 | 620 | 2.8 | 1.4 | 950 | -290 |
| 8 | 240 | 361 | 41.6 | 20.8 | 551 | -171 |
| 9 | -185 | 724 | -14.8 | -7.4 | 1194 | -254 |
| 10 | 235 | 1710 | 7.92 | 4.0 | 2605 | -815 |
| 11 | -240 | 1040 | -13.35 | 6.7 | 1550 | -530 |
| 12 | -200 | 404 | -29.7 | 14.8 | 644 | -160 |
| 13 | 0 | 410 | 0 | 0 | 700 | -120 |
| 14 | 1215 | 1750 | 25.2 | 12.6 | 2605 | -895 |
| 15 | 535 | 1790 | 17.4 | 8.7 | 2375 | -1205 |
| 16 | -305 | 881 | -20.25 | -10.1 | 1396 | -366 |
| 17 | 102 | 499 | 11.8 | 5.9 | 797 | -201 |
| 18 | 68 | 375 | 10.45 | 5.2 | 657 | -93 |
| 19 | -230 | 453 | -30.5 | -15.2 | 983 | 77 |
| 20 | 503 | 2770 | 10.45 | 5.2 | 3762 | -1778 |
| 21 | 390 | 3450 | 6.5 | 3.2 | 4750 | -2150 |
| 22 | -68 | 1262 | -3.1 | -1.6 | 2060 | -464 |
| 23 | 55 | 424 | 7.45 | 2.7 | 1074 | 226 |
| 24 | -100 | 270 | -21.8 | -10.9 | 420 | -120 |
| 25 | -25 | 355 | -4.0 | -2.0 | 580 | -130 |
| 26 | 15 | 1015 | .85 | .4 | 1610 | -420 |
| 27 | 62 | 284 | 12.6 | 6.3 | 492 | -76 |

## TABLE VIII
## Calculation of Principal Strains

Panel No. 1 Load 120,000 pounds

| | A | B | C | D | E |
|---|---|---|---|---|---|
| Gage No. | A axis strain | B axis strain | C axis strain | | |
| | | | | ½ (A+B) | A-D |
| 1 | 0940 | 0720 | -0230 | 355 | 585 |
| 2 | 4440 | 3220 | -0940 | -1750 | 2690 |
| 3 | 1450 | 0580 | -0170 | 640 | 810 |
| 4 | 4680 | 2380 | -1260 | 1710 | 2970 |
| 5 | 6810 | 2300 | -2335 | 2238 | 4572 |
| 6 | 8150 | 2340 | -3530 | 2310 | 5840 |
| 7 | 1310 | 0480 | -0460 | 425 | 885 |
| 8 | 0630 | 0600 | -0110 | 260 | 370 |
| 9 | 1550 | 0285 | -0130 | 710 | 840 |
| 10 | 3590 | 1760 | -1140 | 1225 | 2365 |
| 11 | 2080 | 0360 | -0560 | 760 | 1320 |
| 12 | 0830 | 0050 | -0160 | 335 | 495 |
| 13 | 0930 | 0360 | -0140 | 395 | 535 |
| 14 | 4370 | 2850 | -1250 | 1560 | 2810 |
| 15 | 3160 | 1390 | -0620 | 1270 | 1890 |
| 16 | 3230 | 0530 | -0440 | 1395 | 1835 |
| 17 | 1065 | 0500 | -0240 | 412 | 653 |
| 18 | 0900 | 0490 | -0190 | 355 | 545 |
| 19 | 1270 | 0500 | -0230 | 520 | 750 |
| 20 | 6920 | 2340 | -2955 | 1982 | 4938 |
| 21 | 5820 | 2110 | -2260 | 1780 | 4040 |
| 22 | 3750 | 1410 | -0770 | 1490 | 2260 |
| 23 | 1450 | 0900 | 0310 | 570 | 880 |
| 24 | 0590 | 0070 | -0140 | 225 | 365 |
| 25 | 0820 | 0280 | -0190 | 315 | 505 |
| 26 | 2170 | 0860 | -0400 | 885 | 1285 |
| 27 | 0685 | 0370 | -0100 | 292 | 393 |

TABLE VIII (continued)
Calculation of Principal Strains

Panel No. 1 Load 120,000 pounds

| | F | G | H | I | J | K |
|---|---|---|---|---|---|---|
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B-D | $(E^2\ F^2)^{\frac{1}{2}}$ | Arc Tan F/E | $\frac{1}{2}$ H | D+G | D-G |
| 1 | 365 | 690 | 32.0 | 16.0 | 1045 | -335 |
| 2 | 1470 | 3060 | 28.7 | 14.4 | 4810 | -1310 |
| 3 | -60 | 810 | -4.3 | -2.2 | 1450 | -170 |
| 4 | 670 | 3040 | 12.7 | 6.4 | 4750 | -1330 |
| 5 | 62 | 4572 | 0.8 | 0.4 | 6810 | -2334 |
| 6 | 30 | 5840 | 0 | 0 | 8150 | -3530 |
| 7 | 55 | 885 | 3.6 | 1.8 | 1310 | -460 |
| 8 | 340 | 502 | 42.6 | 21.3 | 767 | -242 |
| 9 | -425 | 933 | -26.8 | -13.4 | 1643 | -223 |
| 10 | 535 | 2420 | 12.8 | 6.4 | 3645 | -1195 |
| 11 | -400 | 1373 | -16.9 | -8.4 | 1533 | -613 |
| 12 | -285 | 570 | -30.0 | -15.0 | 905 | -335 |
| 13 | -35 | 535 | -3.8 | -1.9 | 930 | -140 |
| 14 | 1290 | 3150 | 24.7 | 12.4 | 4710 | -1590 |
| 15 | 120 | 1890 | 3.6 | 1.8 | 3160 | -620 |
| 16 | -865 | 2030 | -25.2 | -12.6 | 3425 | -635 |
| 17 | 88 | 660 | 7.7 | 3.8 | 1072 | -248 |
| 18 | 135 | 560 | 13.9 | 7.0 | 915 | -205 |
| 19 | -20 | 750 | -1.5 | -0.8 | 1270 | -230 |
| 20 | 358 | 4938 | 4.1 | 2.0 | 6920 | -2956 |
| 21 | 330 | 4040 | 4.7 | 2.4 | 5820 | -2260 |
| 22 | -80 | 2260 | -2.0 | -1.0 | 3750 | -770 |
| 23 | 330 | 940 | 20.5 | 10.2 | 1510 | -370 |
| 24 | -155 | 397 | -23.0 | -11.5 | 622 | -172 |
| 25 | -35 | 505 | -4.0 | -2.0 | 820 | -190 |
| 26 | -25 | 1285 | -1.1 | -0.6 | 2170 | -400 |
| 27 | 78 | 400 | 11.2 | 5.6 | 692 | -7 |

## TABLE IX
## Calculation of Principal Strains

Panel No. 1 Load 140,000 pounds

| | A | B | C | D | E |
|---|---|---|---|---|---|
| Gage No. | A axis strain | B axis strain | C axis strain | | |
| | | | | ½(A+B) | A-D |
| 1 | 1260 | 0910 | -0260 | 500 | 760 |
| 2 | 6870 | 4380 | -1080 | 2895 | 3975 |
| 3 | 2150 | 0770 | -0320 | 915 | 1235 |
| 4 | 6640 | 3030 | -1630 | 2505 | 4135 |
| 5 | 8770 | 2950 | -2770 | 3000 | 5770 |
| 6 | 9500 | 2950 | -3710 | 2895 | 6605 |
| 7 | 2090 | 0660 | -0870 | 610 | 1480 |
| 8 | 0880 | 0780 | -0150 | 365 | 515 |
| 9 | 2320 | 0435 | 0040 | 1180 | 1140 |
| 10 | 6290 | 2500 | -1480 | 2405 | 3885 |
| 11 | 3760 | 1210 | -0650 | 1555 | 2205 |
| 12 | 1210 | 0110 | -0230 | 490 | 720 |
| 13 | 1230 | 0430 | -0180 | 525 | 705 |
| 14 | 6190 | 3320 | -1440 | 2375 | 3815 |
| 15 | 4510 | 1790 | -1180 | 1665 | 2845 |
| 16 | 5700 | 1230 | -0810 | 2445 | 3255 |
| 17 | 1585 | 0600 | -0460 | 562 | 1023 |
| 18 | 1290 | 0510 | -0270 | 510 | 780 |
| 19 | 1860 | 0780 | 0240 | 1050 | 810 |
| 20 | 8790 | 3210 | -3285 | 2752 | 6040 |
| 21 | 7830 | 2880 | -2600 | 2615 | 5215 |
| 22 | 6170 | 2210 | -1260 | 2455 | 3715 |
| 23 | 1110 | 0970 | 0385 | 748 | 362 |
| 24 | 0940 | 0030 | -0250 | 345 | 595 |
| 25 | 1270 | 0310 | -0360 | 455 | 815 |
| 26 | 3690 | 1120 | -0450 | 1620 | 2070 |
| 27 | 0975 | 0420 | -0160 | 408 | 567 |

TABLE IX (Continued)
Calculation of Principal Strains

| | F | G | H | I | J | K |
|---|---|---|---|---|---|---|
| Panel No. 1 Load 140,000 pounds | | | | | | |
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B-D | $(E^2 F^2)^{\frac{1}{2}}$ | Arc Tan F/E | $\frac{1}{2}$ H | D+G | D-G |
| 1 | 410 | 865 | 28.3 | 14.2 | 1365 | -365 |
| 2 | 1485 | 4240 | 20.5 | 10.2 | 7135 | -1345 |
| 3 | -145 | 1250 | -6.69 | -3.3 | 2165 | -335 |
| 4 | 525 | 4170 | 7.22 | 3.6 | 6675 | -1665 |
| 5 | -50 | 5770 | -5.0 | -2.5 | 8770 | -2770 |
| 6 | 55 | 6605 | 4.8 | 2.4 | 9500 | -3710 |
| 7 | 50 | 1570 | 18.6 | 1.3 | 2180 | -960 |
| 8 | 415 | 662 | 38.8 | 19.4 | 1027 | -297 |
| 9 | -745 | 1360 | -33.2 | -16.6 | 2540 | -180 |
| 10 | 95 | 3890 | 1.4 | 0.7 | 6295 | -1485 |
| 11 | -345 | 2230 | -8.88 | -4.4 | 3785 | -675 |
| 12 | -380 | 814 | -27.8 | -13.9 | 1304 | -324 |
| 13 | -95 | 713 | -7.66 | -3.83 | 1238 | -188 |
| 14 | 945 | 3930 | 13.9 | 7.0 | 6305 | -1555 |
| 15 | 125 | 2845 | 2.5 | 1.2 | 4510 | -1180 |
| 16 | -1215 | 3470 | -20.5 | -10.2 | 5915 | -1025 |
| 17 | 38 | 1023 | 2.1 | 1.0 | 1585 | -461 |
| 18 | 0 | 780 | 0 | 0 | 1290 | -270 |
| 19 | -270 | 856 | -18.4 | -92 | 1906 | 194 |
| 20 | 458 | 6040 | 4.4 | 2.2 | 8792 | -3288 |
| 21 | 265 | 5215 | 2.9 | 1.5 | 7830 | -2600 |
| 22 | -245 | 3720 | -3.8 | -1.9 | 6175 | -1265 |
| 23 | 222 | 425 | 31.5 | 15.8 | 1173 | 323 |
| 24 | -315 | 674 | -27.9 | -14.0 | 1019 | -329 |
| 25 | -145 | 826 | -10.1 | -5.0 | 1281 | -371 |
| 26 | -500 | 2130 | -13.55 | -6.8 | 3750 | -510 |
| 27 | 12 | 567 | 1.2 | .6 | 975 | -159 |

# TABLE X

## Calculation of Principal Strains

Panel No. 2 Load 20,000 pounds

| | A | B | C | D | E |
|---|---|---|---|---|---|
| Gage No. | A Axis strain | B Axis strain | C Axis strain | ½ (A+B) | A–D |
| 1 | 50 | 40 | 0 | 25 | 25 |
| 2 | 120 | 90 | -40 | 40 | 80 |
| 3 | 320 | 170 | -70 | 125 | 70 |
| 4 | 310 | 130 | -100 | 105 | 205 |
| 5 | 300 | 50 | -50 | 125 | 175 |
| 6 | 220 | 20 | -30 | 95 | 125 |
| 7 | 160 | 40 | -30 | 65 | 95 |
| 8 | 140 | 10 | -80 | 30 | 110 |
| 9 | 320 | 130 | -60 | 130 | 190 |
| 10 | 500 | 220 | -60 | 220 | 280 |
| 11 | 540 | 220 | -110 | 215 | 325 |
| 12 | 730 | 330 | -100 | 315 | 415 |
| 13 | 580 | 390 | -100 | 240 | 340 |
| 14 | 420 | 150 | -80 | 170 | 250 |
| 15 | 250 | 50 | -90 | 80 | 170 |
| 16 | 150 | 10 | -90 | 30 | 120 |
| 17 | 70 | -10 | -20 | 25 | 45 |
| 18 | 170 | 20 | 0 | 85 | 85 |
| 19 | 470 | 250 | -60 | 205 | 265 |
| 20 | -20 | 30 | 0 | -10 | -10 |
| 21 | 150 | 140 | -10 | 70 | 80 |
| 22 | 150 | 140 | -20 | 65 | 85 |
| 23 | | | | | |
| 24 | 350 | 140 | -60 | 145 | 205 |
| 25 | 270 | 30 | -60 | 105 | 165 |
| 26 | 210 | 0 | -40 | 135 | 75 |
| 27 | 170 | 10 | -40 | 115 | 55 |
| 28 | 30 | 0 | -70 | -20 | 10 |
| 29 | -110 | -110 | -150 | -130 | 20 |
| 30 | 20 | 0 | -100 | -40 | 60 |
| 31 | -160 | -170 | -180 | -170 | 10 |
| 32 | -130 | -180 | -160 | -145 | 15 |
| 33 | 80 | -20 | -110 | -15 | 65 |
| 34 | 170 | 50 | -40 | 65 | 105 |
| 35 | 80 | -20 | -30 | 25 | 55 |
| 36 | 180 | 120 | -100 | 40 | 140 |
| 37 | -10 | | | | |
| 38 | 110 | | | | |
| 39 | 430 | | | | |
| 40 | 230 | | | | |
| 41 | 110 | | | | |
| 42 | 200 | | | | |

TABLE X (continued)
Calculation of Principal Strains

Panel No. 2 Load 20,000 pounds

| | F | G | H | I | J | K |
|---|---|---|---|---|---|---|
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B-D | $(E^2+F^2)^{\frac{1}{2}}$ | Arc Tan F/E | $\frac{1}{2}$ H | D+G | D-G |
| 1 | 15 | 29 | 30.7 | 15.4 | 54 | -4 |
| 2 | 50 | 95 | 31.8 | 15.9 | 135 | -55 |
| 3 | 45 | 84 | 32.5 | 16.2 | 209 | 41 |
| 4 | 25 | 209 | 6.9 | 3.4 | 314 | -104 |
| 5 | -75 | 192 | -23.0 | -11.5 | 317 | -67 |
| 6 | -75 | 147 | -30.7 | -15.4 | 242 | -52 |
| 7 | -25 | 99 | -14.2 | -7.1 | 164 | -34 |
| 8 | -20 | 113 | -10.2 | -5.1 | 143 | -83 |
| 9 | 0 | 190 | 0 | 0 | 320 | -60 |
| 10 | 0 | 280 | 0 | 0 | 500 | -60 |
| 11 | 5 | 325 | 0.9 | .4 | 540 | -110 |
| 12 | 15 | 415 | 2.1 | 1.0 | 730 | -100 |
| 13 | 50 | 347 | 8.3 | 4.2 | 587 | -107 |
| 14 | -20 | 250 | -4.6 | -2.3 | 420 | -80 |
| 15 | -30 | 174 | -9.9 | -5.0 | 254 | -94 |
| 16 | -20 | 123 | -9.4 | -4.7 | 153 | -93 |
| 17 | -35 | 57 | -37.6 | -18.8 | 82 | -32 |
| 18 | -65 | 107 | -37.2 | -18.6 | 192 | -22 |
| 19 | -45 | 271 | -9.6 | -4.8 | 476 | -66 |
| 20 | 40 | 42 | 104.0 | 52 | 32 | -52 |
| 21 | 70 | 107 | 40.9 | 20.4 | 177 | -37 |
| 22 | 75 | 114 | 41.2 | 20.6 | 179 | -49 |
| 23 | | | | | | |
| 24 | -5 | 205 | -1.4 | -0.7 | 350 | -50 |
| 25 | -75 | 183 | -24.2 | -12.1 | 288 | -78 |
| 26 | -135 | 156 | -61.2 | -30.6 | 291 | -21 |
| 27 | -105 | 120 | -62.6 | -31.3 | 235 | -5 |
| 28 | 20 | 26 | 67.5 | 33.8 | 6 | -46 |
| 29 | 20 | 28 | 45 | 22.5 | -102 | -158 |
| 30 | 40 | 73 | 33.4 | 16.7 | 33 | -113 |
| 31 | 0 | 10 | 0 | 0 | -160 | -180 |
| 32 | -35 | 38 | -67 | -33.5 | -107 | -183 |
| 33 | -5 | 65 | -4.4 | -2.2 | 50 | -80 |
| 34 | -15 | 107 | -8.0 | -4.0 | 172 | -42 |
| 35 | -45 | 71 | -39.0 | -19.5 | 96 | -46 |
| 36 | 80 | 162 | 29.5 | 14.8 | 202 | -122 |

TABLE XI
Calculation of Principal Strains

| Panel No. 2 Load 40,000 pounds | A | B | C | D | E |
|---|---|---|---|---|---|
| Gage No. | A Axis strain | B Axis strain | C Axis strain | ½ (A+B) | A–D |
| 1 | 190 | 130 | -10 | 90 | 100 |
| 2 | 300 | 210 | -90 | 105 | 195 |
| 3 | 710 | 330 | -140 | 285 | 425 |
| 4 | 730 | 350 | -190 | 270 | 460 |
| 5 | 610 | 130 | -110 | 250 | 360 |
| 6 | 450 | 90 | -60 | 195 | 255 |
| 7 | 320 | 90 | -50 | 135 | 185 |
| 8 | 340 | 40 | -190 | 75 | 265 |
| 9 | 700 | 300 | -120 | 290 | 410 |
| 10 | 1050 | 480 | -120 | 465 | 585 |
| 11 | 1050 | 450 | -240 | 405 | 645 |
| 12 | 1440 | 670 | -190 | 625 | 815 |
| 13 | 170 | 570 | -180 | –5 | 175 |
| 14 | 850 | 290 | -180 | 335 | 515 |
| 15 | 550 | 130 | -190 | 180 | 370 |
| 16 | 360 | 50 | -210 | 75 | 285 |
| 17 | 170 | 0 | -40 | 65 | 105 |
| 18 | 400 | 80 | 0 | 200 | 200 |
| 19 | 1400 | 760 | -90 | 655 | 745 |
| 20 | 80 | 110 | 10 | 45 | 35 |
| 21 | 350 | 290 | -20 | 165 | 185 |
| 22 | 310 | 260 | -60 | 125 | 185 |
| 23 |  |  |  |  |  |
| 24 | 730 | 370 | -120 | 305 | 425 |
| 25 | 500 | 50 | -140 | 180 | 320 |
| 26 | 370 | 20 | -80 | 145 | 225 |
| 27 | 360 | 50 | -60 | 150 | 210 |
| 28 | 70 | 0 | -150 | -40 | 110 |
| 29 | -180 | -210 | -310 | -245 | 65 |
| 30 | 120 | 10 | -220 | -50 | 170 |
| 31 | -240 | -260 | -340 | -290 | 50 |
| 32 | -220 | -370 | -330 | -275 | 55 |
| 33 | 220 | -40 | -240 | -10 | 230 |
| 34 | 380 | 130 | -100 | 140 | 240 |
| 35 | 180 | -20 | -70 | 45 | 135 |
| 36 | 340 | 240 | -160 | 90 | 250 |
| 37 | -70 |  |  |  |  |
| 38 | 30 |  |  |  |  |
| 39 | 530 |  |  |  |  |
| 40 | 210 |  |  |  |  |
| 41 | 50 |  |  |  |  |
| 42 | 280 |  |  |  |  |

## TABLE XI (continued)
## Calculation of Principal Strains

Panel No. 2 Load 40,000 pounds

| | F | G | H | I | J | K |
|---|---|---|---|---|---|---|
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B-D | $(E^2+F^2)^{\frac{1}{2}}$ | Arc Tan F/E | ½ H | D+G | D-G |
| 1 | 40 | 109 | 21.6 | 10.8 | 199 | -19 |
| 2 | 105 | 223 | 28.1 | 14.0 | 328 | -118 |
| 3 | 45 | 431 | 6.0 | 3.0 | 716 | -146 |
| 4 | 80 | 471 | 9.8 | 4.9 | 741 | -201 |
| 5 | -120 | 383 | -18.3 | -9.2 | 633 | -133 |
| 6 | -105 | 278 | -22.2 | -11.1 | 473 | -83 |
| 7 | -45 | 191 | -16.6 | -6.8 | 326 | -56 |
| 8 | -35 | 270 | -7.4 | -3.7 | 345 | -195 |
| 9 | 10 | 410 | 1.4 | 0.7 | 700 | -120 |
| 10 | 15 | 585 | 1.5 | 0.8 | 1050 | -120 |
| 11 | 45 | 645 | 4.0 | 2.0 | 1050 | -240 |
| 12 | 45 | 815 | 3.2 | 1.6 | 1440 | -190 |
| 13 | 575 | 605 | 73.2 | 36.6 | 600 | -610 |
| 14 | -45 | 515 | -5.0 | -2.5 | 850 | -180 |
| 15 | -50 | 376 | -7.6 | -3.8 | 556 | -194 |
| 16 | -25 | 285 | -5.0 | -2.5 | 360 | -210 |
| 17 | -65 | 124 | -31.5 | -15.8 | 189 | -59 |
| 18 | -120 | 234 | -30.8 | -15.4 | 434 | -34 |
| 19 | 105 | 760 | 7.8 | 4.0 | 1415 | -105 |
| 20 | 65 | 74 | 61.9 | 31.0 | 119 | -29 |
| 21 | 125 | 225 | 33.8 | 16.9 | 390 | -60 |
| 22 | 135 | 230 | 35.9 | 18.0 | 355 | -105 |
| 23 | | | | | | |
| 24 | 65 | 434 | 8.6 | 4.3 | 739 | -129 |
| 25 | -130 | 348 | -21.9 | -11.4 | 528 | -168 |
| 26 | -125 | 259 | -28.8 | -14.4 | 404 | -114 |
| 27 | -100 | 234 | -25.3 | -12.6 | 384 | -84 |
| 28 | 40 | 118 | 19.8 | 9.9 | 78 | -158 |
| 29 | 35 | 74 | 28.1 | 14.0 | -171 | -319 |
| 30 | 60 | 182 | 19.3 | 9.6 | 132 | -232 |
| 31 | 30 | 58 | 30.8 | 15.4 | -232 | -348 |
| 32 | -95 | 111 | -60.2 | -30.1 | -164 | -386 |
| 33 | -30 | 234 | -7.4 | -3.7 | 224 | -244 |
| 34 | -10 | 240 | -2.4 | -1.2 | 380 | -100 |
| 35 | -65 | 151 | -25.5 | -12.8 | 196 | -106 |
| 36 | 150 | 293 | 30.8 | 15.4 | 383 | -203 |

## TABLE XII
## Calculation of Principal Strains

Panel No. 2 Load 60,000 pounds

|  | A | B | C | D | E |
|---|---|---|---|---|---|
| Gage | A Axis strain | B Axis strain | C Axis strain |  |  |
|  |  |  |  | ½ (A+B) | A–D |
| 1 | 340 | 210 | -10 | 165 | 175 |
| 2 | 500 | 310 | -130 | 185 | 315 |
| 3 | 1130 | 500 | -180 | 475 | 655 |
| 4 | 1190 | 610 | -270 | 460 | 730 |
| 5 | 930 | 190 | -190 | 370 | 560 |
| 6 | 670 | 160 | -80 | 295 | 375 |
| 7 | 480 | 140 | -70 | 205 | 275 |
| 8 | 560 | 90 | -310 | 125 | 435 |
| 9 | 1100 | 450 | -200 | 450 | 650 |
| 10 | 1630 | 740 | -200 | 715 | 915 |
| 11 | 1560 | 670 | -380 | 590 | 970 |
| 12 | 2430 | 1150 | -260 | 1085 | 1345 |
| 13 | 2050 | 1080 | -240 | 905 | 1145 |
| 14 | 1100 | 390 | -570 | 265 | 835 |
| 15 | 1340 | 360 | -350 | 495 | 845 |
| 16 | 670 | 120 | -310 | 180 | 490 |
| 17 | 290 | 20 | -70 | 110 | 180 |
| 18 | 670 | 160 | 0 | 335 | 335 |
| 19 | 2740 | 1430 | -220 | 1260 | 1480 |
| 20 | 260 | 220 | -30 | 115 | 135 |
| 21 | 550 | 430 | -20 | 265 | 285 |
| 22 | 500 | 360 | -100 | 200 | 300 |
| 23 |  |  |  |  |  |
| 24 | 1080 | 600 | -160 | 460 | 620 |
| 25 | 710 | 50 | -240 | 235 | 475 |
| 26 | 530 | 50 | -120 | 205 | 325 |
| 27 | 530 | 100 | -70 | 230 | 300 |
| 28 | 130 | 0 | -230 | -50 | 180 |
| 29 | -220 | -320 | -480 | -350 | 130 |
| 30 | 280 | 70 | -310 | -15 | 295 |
| 31 | -320 | -370 | -500 | -410 | 90 |
| 32 | -300 | -630 | -540 | -420 | 120 |
| 33 | 530 | 0 | -410 | 60 | 470 |
| 34 | 1070 | 550 | -210 | 430 | 640 |
| 35 | 290 | -20 | -110 | 90 | 200 |
| 36 | 700 | 350 | -320 | 140 | 560 |
| 37 | -130 |  |  |  |  |
| 38 | -100 |  |  |  |  |
| 39 | 530 |  |  |  |  |
| 40 | 140 |  |  |  |  |
| 41 | -50 |  |  |  |  |
| 42 | 260 |  |  |  |  |

## TABLE XII (continued)
## Calculation of Principal Strains

| Panel No. 2 Load 60,000 pounds | | | | | | |
|---|---|---|---|---|---|---|
| | F | G | H | I | J | K |
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B–D | $(E^2+F^2)^{\frac{1}{2}}$ | Arc Tan F/E | $\frac{1}{2}$ H | D+G | D–G |
| 1 | 45 | 182 | 14.3 | 7.2 | 347 | -17 |
| 2 | 125 | 342 | 21.5 | 10.8 | 527 | -157 |
| 3 | 25 | 655 | 2.2 | 1.1 | 1130 | -180 |
| 4 | 150 | 753 | 11.5 | 5.8 | 1213 | -293 |
| 5 | -180 | 592 | -17.7 | -8.8 | 962 | -222 |
| 6 | -135 | 403 | -19.6 | -9.8 | 698 | -108 |
| 7 | -65 | 285 | -13.2 | -6.6 | 490 | -80 |
| 8 | -35 | 435 | -4.6 | -2.3 | 560 | -310 |
| 9 | 0 | 650 | 0 | 0 | 1100 | -200 |
| 10 | 25 | 915 | 1.6 | 0.8 | 1630 | -200 |
| 11 | 80 | 970 | 4.7 | 2.4 | 1560 | -380 |
| 12 | -35 | 1345 | -1.5 | -0.8 | 2430 | -260 |
| 13 | 175 | 1170 | 8.6 | 4.3 | 2075 | -265 |
| 14 | 125 | 850 | 8.45 | 4.2 | 1115 | -585 |
| 15 | -135 | 863 | -9.0 | -4.5 | 1358 | -368 |
| 16 | -60 | 498 | -6.9 | -3.4 | 678 | -318 |
| 17 | -90 | 202 | -26.4 | -13.2 | 312 | -92 |
| 18 | -175 | 381 | -27.4 | -13.7 | 716 | -46 |
| 19 | 170 | 1500 | 6.5 | 3.2 | 2760 | -240 |
| 20 | 105 | 172 | 37.6 | 18.8 | 287 | -57 |
| 21 | 165 | 332 | 29.8 | 14.9 | 597 | -67 |
| 22 | 160 | 342 | 27.9 | 14.0 | 542 | -142 |
| 23 | | | | | | |
| 24 | 140 | 642 | 12.6 | 6.3 | 1102 | -182 |
| 25 | -185 | 514 | -21.1 | -10.6 | 749 | -279 |
| 26 | -155 | 363 | -25.3 | -12.6 | 568 | -158 |
| 27 | -130 | 330 | -23.2 | -11.6 | 560 | -100 |
| 28 | 50 | 188 | 15.4 | 7.7 | 138 | -238 |
| 29 | 30 | 134 | 12.9 | 6.4 | -216 | -484 |
| 30 | 85 | 310 | 15.9 | 8.0 | 295 | -325 |
| 31 | 40 | 99 | 23.8 | 11.9 | -311 | -509 |
| 32 | -210 | 243 | -60.4 | -30.2 | -177 | -663 |
| 33 | -60 | 480 | -7.2 | -3.6 | 540 | -420 |
| 34 | 120 | 656 | 10.5 | 5.2 | 1086 | -226 |
| 35 | -110 | 230 | -28.6 | -14.3 | 320 | -140 |
| 36 | 210 | 604 | 20.4 | 10.2 | 744 | -464 |

## Table XIII
## Calculation of Principal Strains

| Panel No. 2 Load 80,000 pounds | | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Gage No. | A Axis strain | B Axis strain | C Axis strain | ½ (A+B) | A–D |
| 1 | 510 | 300 | -30 | 240 | 270 |
| 2 | 710 | -410 | -160 | 275 | 435 |
| 3 | 1870 | 750 | -240 | 815 | 1055 |
| 4 | 1730 | 970 | -350 | 690 | 1040 |
| 5 | 1360 | 220 | -340 | 570 | 790 |
| 6 | 860 | 230 | -40 | 410 | 450 |
| 7 | 640 | 190 | -80 | 280 | 360 |
| 8 | 850 | 150 | -440 | 205 | 645 |
| 9 | 2070 | 910 | -300 | 885 | 1185 |
| 10 | 2880 | 1390 | -270 | 1305 | 1575 |
| 11 | 2070 | 880 | -600 | 735 | 1335 |
| 12 | 4470 | 2050 | -320 | 2075 | 2395 |
| 13 | 3190 | 1710 | -300 | 1445 | 1745 |
| 14 | 1680 | 520 | -390 | 645 | 1035 |
| 15 | 3220 | 770 | -550 | 1335 | 1885 |
| 16 | 1160 | 270 | -440 | 360 | 800 |
| 17 | 430 | 50 | -100 | 165 | 265 |
| 18 | 940 | 240 | 10 | 475 | 465 |
| 19 | 4530 | 2050 | -500 | 2015 | 2515 |
| 20 | 460 | 360 | -50 | 205 | 255 |
| 21 | 760 | 560 | -20 | 370 | 390 |
| 22 | 690 | 450 | -130 | 280 | 410 |
| 23 | | | | | |
| 24 | 1390 | 870 | -190 | 600 | 790 |
| 25 | 910 | -20 | -400 | 255 | 655 |
| 26 | 650 | 90 | -140 | 255 | 395 |
| 27 | 660 | 130 | -50 | 305 | 355 |
| 28 | 160 | 30 | -310 | -75 | 235 |
| 29 | -360 | -500 | -690 | -525 | 165 |
| 30 | 470 | 190 | -340 | 65 | 405 |
| 31 | -310 | -490 | -760 | -535 | 225 |
| 32 | -280 | -930 | -770 | -525 | 245 |
| 33 | 1230 | 280 | -600 | 315 | 915 |
| 34 | 2900 | 1650 | -300 | 1300 | 1600 |
| 35 | 400 | -10 | -140 | 130 | 270 |
| 36 | 1440 | 460 | -610 | 415 | 1025 |
| 37 | -160 | | | | |
| 38 | -240 | | | | |
| 39 | 520 | | | | |
| 40 | 90 | | | | |
| 41 | -170 | | | | |
| 42 | 240 | | | | |

## TABLE XIII(continued)
## Calculation of Principal Strains

Panel No. 2 Load 80,000

|  | F | G | H | I | J | K |
|---|---|---|---|---|---|---|
| Gage No. |  |  |  | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
|  | B–D | $(E^2+F^2)^{\frac{1}{2}}$ | Arc Tan F/E | $\frac{1}{2}$ H | D+G | D–G |
| 1 | 60 | 280 | 12.4 | 6.2 | 520 | -40 |
| 2 | 135 | 460 | 17.1 | 8.6 | 735 | -185 |
| 3 | -65 | 1055 | -3.5 | 1.8 | 1870 | -240 |
| 4 | 300 | 1090 | 16.0 | 8.0 | 1780 | -400 |
| 5 | -350 | 870 | -23.7 | -11.8 | 1440 | -300 |
| 6 | -180 | 490 | -21.6 | -10.8 | 900 | -80 |
| 7 | -90 | 375 | -13.9 | -7.0 | 655 | -95 |
| 8 | -55 | 645 | -4.9 | -2.4 | 850 | -440 |
| 9 | 25 | 1185 | 1.5 | 0.8 | 2070 | -300 |
| 10 | 85 | 1575 | 3.1 | 1.6 | 2880 | -270 |
| 11 | 145 | 1350 | 6.2 | 3.1 | 2085 | -615 |
| 12 | -25 | 2395 | -0.6 | -0.3 | 4470 | -320 |
| 13 | 265 | 1780 | 8.6 | 4.3 | 3225 | -335 |
| 14 | -125 | 1050 | -6.8 | -3.4 | 1695 | -405 |
| 15 | -565 | 1990 | -16.5 | -8.2 | 3325 | -655 |
| 16 | -90 | 814 | -6.8 | -3.4 | 1174 | -454 |
| 17 | -115 | 291 | -23.2 | -11.6 | 456 | -126 |
| 18 | -235 | 525 | -26.6 | -13.3 | 1000 | -50 |
| 19 | 35 | 2515 | 0.8 | 0.4 | 4530 | -500 |
| 20 | 155 | 301 | 31.0 | 15.5 | 506 | -96 |
| 21 | 190 | 437 | 25.8 | 12.9 | 807 | -67 |
| 22 | 170 | 448 | 22.3 | 11.2 | 728 | -168 |
| 23 |  |  |  |  |  |  |
| 24 | 270 | 843 | 18.7 | 9.4 | 1443 | -243 |
| 25 | -275 | 716 | -22.6 | -11.3 | 971 | -461 |
| 26 | -165 | 432 | -22.5 | -11.2 | 687 | -177 |
| 27 | -175 | 400 | -26.0 | -13.0 | 705 | -95 |
| 28 | 105 | 260 | 23.9 | 12.0 | 185 | -335 |
| 29 | 25 | 168 | 8.5 | 4.2 | -357 | -693 |
| 30 | 125 | 428 | 17.0 | 8.5 | 493 | -363 |
| 31 | 45 | 232 | 11.2 | 5.6 | -303 | -767 |
| 32 | -405 | 476 | -59.0 | -29.5 | -49 | -1001 |
| 33 | -35 | 915 | 2.2 | 1.1 | 1230 | -600 |
| 34 | 350 | 1660 | 12.2 | 6.1 | 2960 | -360 |
| 35 | -140 | 305 | 27.4 | 13.7 | 435 | -175 |
| 36 | 45 | 1025 | 2.5 | 1.2 | 1440 | -610 |

## Table XIV
## Calculation of Principal Strains

| Panel No. 2 Load 100,000 pounds | | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Gage No. | A Axis strain | B Axis strain | C Axis strain | ½ (A+B) | A–D |
| 1 | 700 | 380 | -30 | 335 | 365 |
| 2 | 890 | 510 | -170 | 360 | 530 |
| 3 | 3440 | 1280 | -360 | 1540 | 1900 |
| 4 | 2300 | 1370 | -410 | 945 | 1355 |
| 5 | 2050 | 280 | -580 | 735 | 1315 |
| 6 | 1050 | 280 | -10 | 520 | 530 |
| 7 | 830 | 240 | -100 | 365 | 465 |
| 8 | 1250 | 230 | -620 | 315 | 935 |
| 9 | 3540 | 1590 | -400 | 1570 | 1970 |
| 10 | 4550 | 2190 | -260 | 2145 | 2405 |
| 11 | 2450 | 1000 | -940 | 755 | 1695 |
| 12 | 6970 | 3190 | -430 | 3270 | 3700 |
| 13 | 4350 | 2350 | -370 | 2140 | 2210 |
| 14 | 3980 | 1140 | -1740 | 1120 | 2860 |
| 15 | 4660 | 1330 | -730 | 1965 | 2695 |
| 16 | 1720 | 410 | -620 | 550 | 1170 |
| 17 | 560 | 60 | -130 | 215 | 345 |
| 18 | 1190 | 300 | 40 | 615 | 575 |
| 19 | 6550 | 2650 | -790 | 2880 | 3670 |
| 20 | 670 | 500 | -60 | 305 | 365 |
| 21 | 950 | 690 | 10 | 480 | 470 |
| 22 | 850 | 520 | -130 | 360 | 490 |
| 23 | | | | | |
| 24 | 1640 | 1160 | -180 | 730 | 910 |
| 25 | 1230 | -140 | -660 | 285 | 945 |
| 26 | 760 | 130 | -140 | 310 | 450 |
| 27 | 780 | 140 | -10 | 385 | 395 |
| 28 | 310 | 70 | -500 | -95 | 405 |
| 29 | -310 | -560 | -1000 | -655 | 345 |
| 30 | 880 | 420 | -350 | 265 | 615 |
| 31 | 180 | -390 | -1060 | -440 | 620 |
| 32 | 0 | -1140 | -990 | -495 | 495 |
| 33 | 3420 | 1230 | -930 | 1245 | 2175 |
| 34 | 4530 | 2650 | -380 | 2075 | 2455 |
| 35 | 490 | -30 | -170 | 160 | 330 |
| 36 | 2420 | 710 | -1030 | 695 | 1725 |
| 37 | -150 | | | | |
| 38 | -290 | | | | |
| 39 | 640 | | | | |
| 40 | 110 | | | | |
| 41 | -190 | | | | |
| 42 | 340 | | | | |

## TABLE XIV (continued)
## Calculation of Principal Strains

Panel No. 2 Load 100,000 pounds

| Gage No. | F | G | H | I | J | K |
|---|---|---|---|---|---|---|
| | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B–D | $(E^2+F^2)^{\frac{1}{2}}$ | Arc Tan F/E | ½ H | D+G | D–G |
| 1 | 45 | 368 | 7.0 | 3.5 | 703 | -33 |
| 2 | 150 | 550 | 15.9 | 8.0 | 910 | -190 |
| 3 | -260 | 2000 | -7.6 | -3.8 | 3540 | -460 |
| 4 | 425 | 1420 | 17.5 | 8.8 | 2365 | -475 |
| 5 | -455 | 1390 | -19.1 | -9.6 | 2125 | -655 |
| 6 | -240 | 581 | -24.4 | -12.2 | 1101 | -61 |
| 7 | -125 | 480 | -15.1 | -7.6 | 845 | -115 |
| 8 | -85 | 935 | -5.1 | -2.6 | 1250 | -620 |
| 9 | 20 | 1980 | 5.8 | 2.9 | 3550 | -410 |
| 10 | 45 | 2405 | 1.0 | 0.5 | 4550 | -260 |
| 11 | 245 | 1710 | 8.2 | 4.1 | 2465 | -955 |
| 12 | -80 | 3700 | -1.3 | -0.6 | 6970 | -430 |
| 13 | 210 | 2210 | 5.5 | 2.8 | 4350 | -70 |
| 14 | 20 | 2860 | 4.0 | 2.0 | 3980 | -1740 |
| 15 | -635 | 2770 | -13.2 | -6.6 | 4735 | -805 |
| 16 | -140 | 1180 | -6.9 | -3.4 | 1730 | -630 |
| 17 | -155 | 378 | -24.2 | -12.1 | 593 | -163 |
| 18 | -315 | 665 | -28.7 | -14.4 | 1280 | -50 |
| 19 | -230 | 3670 | -3.6 | -1.8 | 6550 | -790 |
| 20 | 195 | 413 | 28.2 | 14.1 | 718 | -108 |
| 21 | 210 | 515 | 24.1 | 12.0 | 995 | -35 |
| 22 | 160 | 515 | 18.1 | 9.0 | 875 | -155 |
| 23 | | | | | | |
| 24 | 430 | 1005 | 25.3 | 12.6 | 1735 | -275 |
| 25 | -425 | 1035 | -24.2 | -12.1 | 1320 | -750 |
| 26 | -180 | 485 | -21.8 | -10.9 | 795 | -175 |
| 27 | -245 | 475 | -31.8 | -15.9 | 860 | -90 |
| 28 | 165 | 438 | 22.2 | 11.1 | 343 | -533 |
| 29 | 95 | 347 | 15.9 | 8.0 | -308 | -1002 |
| 30 | 155 | 634 | 14.2 | 7.1 | 899 | -369 |
| 31 | 50 | 620 | 4.6 | 2.3 | 180 | -1060 |
| 32 | -645 | 813 | -52.5 | -26.2 | 318 | -1308 |
| 33 | -15 | 2175 | 0 | 0 | 3420 | -930 |
| 34 | 575 | 2510 | 13.1 | 6.6 | 4585 | -435 |
| 35 | -190 | 380 | -30.0 | -15.0 | 540 | -220 |
| 36 | 15 | 1725 | 0 | 0 | 2420 | -1030 |

## TABLE XV
## Calculation of Principal Strains

| Panel No. 2 Load 120,000 pounds | | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Gage No. | A Axis strain | B Axis strain | C Axis strain | ½ (A+B) | A–D |
| 1 | 920 | 500 | -30 | 445 | 475 |
| 2 | 1130 | 600 | -200 | 465 | 665 |
| 3 | 5470 | 2750 | -800 | 2335 | 3135 |
| 4 | 3230 | 1900 | -520 | 1355 | 1875 |
| 5 | 3480 | 810 | -660 | 1410 | 2430 |
| 6 | 1330 | 390 | 20 | 675 | 655 |
| 7 | 1070 | 330 | -160 | 455 | 615 |
| 8 | 1740 | 300 | -810 | 465 | 1275 |
| 9 | 5160 | 2290 | -520 | 2320 | 2840 |
| 10 | 6090 | 2770 | -210 | 2940 | 3150 |
| 11 | 3010 | 1320 | -1320 | 845 | 2165 |
| 12 | 10450 | 4700 | -750 | 4850 | 5600 |
| 13 | 5470 | 2880 | -370 | 2550 | 2920 |
| 14 | 7990 | 2890 | -1440 | 3275 | 4715 |
| 15 | 6050 | 2030 | -920 | 2565 | 3485 |
| 16 | 2350 | 550 | -840 | 755 | 1595 |
| 17 | 740 | 70 | -180 | 280 | 460 |
| 18 | 1480 | 370 | 80 | 780 | 700 |
| 19 | 8210 | 3230 | -1180 | 3515 | 4695 |
| 20 | 930 | 670 | -90 | 420 | 510 |
| 21 | 1170 | 860 | 110 | 640 | 530 |
| 22 | 1060 | 510 | -190 | 435 | 625 |
| 23 | | | | | |
| 24 | 2090 | 1500 | -240 | 925 | 1165 |
| 25 | 2070 | -80 | -820 | 625 | 1445 |
| 26 | 970 | 160 | -160 | 405 | 565 |
| 27 | 940 | 180 | 40 | 490 | 450 |
| 28 | 730 | 120 | -740 | -5 | 735 |
| 29 | 150 | -340 | -1250 | -550 | 700 |
| 30 | 2040 | 890 | -420 | 810 | 1230 |
| 31 | 1640 | 270 | -1610 | 15 | 1625 |
| 32 | 640 | -1060 | -1050 | 205 | 435 |
| 33 | 7220 | 2930 | -1470 | 2875 | 4345 |
| 34 | 6060 | 3350 | -470 | 2795 | 3265 |
| 35 | 560 | -80 | -190 | 185 | 375 |
| 36 | 3410 | 1050 | -1410 | 1000 | 2410 |
| 37 | -90 | | | | |
| 38 | -300 | | | | |
| 39 | 840 | | | | |
| 40 | 210 | | | | |
| 41 | -160 | | | | |
| 42 | 510 | | | | |

## TABLE XV (continued)
## Calculation of Principal Strains

| Panel No. 2 Load 120,000 pounds | | | | | | |
|---|---|---|---|---|---|---|
| | F | G | H | I | J | K |
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B-D | $(E^2+F^2)^{\frac{1}{2}}$ | Arc Tan F/E | $\frac{1}{2}$ H | D+G | D-G |
| 1 | 55 | 479 | 6.6 | 3.3 | 924 | -34 |
| 2 | 135 | 678 | 11.5 | 5.7 | 1143 | -213 |
| 3 | 415 | 3160 | 7.5 | 3.8 | 5495 | -825 |
| 4 | 545 | 1950 | 16.2 | 8.1 | 3305 | -615 |
| 5 | -600 | 2500 | -13.7 | -6.8 | 3910 | -1090 |
| 6 | -285 | 715 | -23.5 | -11.8 | 1390 | -40 |
| 7 | -125 | 628 | -11.5 | -5.8 | 1083 | -173 |
| 8 | -165 | 1280 | -7.4 | -3.7 | 1745 | -815 |
| 9 | -30 | 2840 | -0.6 | -0.3 | 5160 | -520 |
| 10 | -170 | 3150 | -3.0 | -1.5 | 6090 | -210 |
| 11 | 475 | 2210 | 12.4 | 6.2 | 3055 | -1365 |
| 12 | -150 | 5600 | -1.5 | -0.8 | 10450 | -750 |
| 13 | 330 | 2940 | 6.5 | 3.2 | 5490 | -390 |
| 14 | -385 | 4715 | -4.7 | -2.4 | 7990 | -1440 |
| 15 | -535 | 3520 | -8.8 | -4.4 | 6085 | -955 |
| 16 | -205 | 1605 | -7.3 | -3.6 | 2360 | -850 |
| 17 | -210 | 506 | -24.5 | -12.2 | 786 | -226 |
| 18 | -410 | 812 | -30.4 | -15.2 | 1592 | -32 |
| 19 | -285 | 4695 | -3.5 | -1.8 | 8210 | -1180 |
| 20 | 250 | 567 | 26.1 | 13.0 | 987 | -147 |
| 21 | 220 | 574 | 22.5 | 11.2 | 1214 | 66 |
| 22 | 75 | 630 | 6.9 | 3.4 | 1065 | -195 |
| 23 | | | | | | |
| 24 | 575 | 1300 | 26.3 | 13.2 | 2225 | -375 |
| 25 | -705 | 1610 | -26.0 | -13.0 | 2235 | -985 |
| 26 | -245 | 615 | -23.5 | -11.8 | 1020 | -210 |
| 27 | -310 | 548 | -34.5 | -17.2 | 1038 | -58 |
| 28 | 125 | 745 | 9.7 | 4.8 | 740 | -750 |
| 29 | 210 | 730 | 16.7 | 8.4 | 180 | -1280 |
| 30 | 80 | 1230 | 3.8 | 1.9 | 2040 | -420 |
| 31 | 255 | 1650 | 8.9 | 4.4 | 1665 | -1635 |
| 32 | -1265 | 1335 | -71.0 | -35.5 | 1540 | -1095 |
| 33 | 55 | 4345 | 0.7 | 0.4 | 7220 | -1470 |
| 34 | 555 | 3300 | 9.7 | 4.8 | 6095 | -505 |
| 35 | -265 | 459 | -35.3 | -17.6 | 644 | -274 |
| 36 | 50 | 2410 | 1.3 | 0.7 | 3410 | -1410 |

## TABLE XVI (continued)
## Calculation of Principal Strains

Panel No. 2 Load 140,000 pounds

| | F | G | H | I | J | K |
|---|---|---|---|---|---|---|
| Gage No. | | | | Angle Principal Strain | Major Principal Strain | Minor Principal Strain |
| | B-D | $(E^2+F^2)^{\frac{1}{2}}$ | Arc Tan F/E | $\frac{1}{2}$ H | D+G | D-G |
| 1 | 65 | 600 | 6.2 | 3.1 | 1165 | -35 |
| 2 | 110 | 815 | 7.8 | 3.9 | 1335 | -295 |
| 3 | 1330 | 4690 | 16.5 | 8.2 | 7960 | -1420 |
| 4 | 690 | 3300 | 12.1 | 6.0 | 5450 | -1150 |
| 5 | -615 | 3140 | -11.3 | -5.6 | 6305 | -975 |
| 6 | -280 | 790 | -20.7 | -10.3 | 1590 | 10 |
| 7 | -95 | 850 | -6.6 | -3.3 | 1410 | -285 |
| 8 | 280 | 1700 | 9.5 | 4.8 | 2360 | -1040 |
| 9 | -90 | 3480 | -1.5 | -0.8 | 6340 | -620 |
| 10 | -220 | 3720 | -3.4 | -1.7 | 7260 | -180 |
| 11 | -1060 | 1700 | -38.6 | -19.3 | 4950 | 1550 |
| 12 | | | | | | |
| 13 | 145 | 3915 | 2.0 | 1.0 | 7490 | -340 |
| 14 | -665 | 6346 | -6.0 | -3.0 | 10801 | -1891 |
| 15 | -620 | 4330 | -8.2 | -4.1 | 7510 | -1150 |
| 16 | -260 | 2050 | -7.3 | -3.6 | 2970 | -1130 |
| 17 | -275 | 683 | -23.8 | -11.9 | 1058 | -308 |
| 18 | -495 | 980 | -30.4 | -15.2 | 1965 | 5 |
| 19 | -420 | 5870 | -4.1 | -2.0 | 10070 | -1670 |
| 20 | 305 | 775 | 23.2 | 11.6 | 1330 | -220 |
| 21 | 245 | 643 | 22.4 | 11.2 | 1468 | 182 |
| 22 | -50 | 1060 | -2.6 | -1.3 | 1720 | -400 |
| 23 | | | | | | |
| 24 | 550 | 2300 | 13.8 | 6.9 | 3820 | -780 |
| 25 | -985 | 2400 | -24.3 | -12.2 | 3565 | -1235 |
| 26 | -440 | 975 | -26.8 | -13.4 | 1595 | -355 |
| 27 | -360 | 633 | -34.7 | -17.4 | 1213 | -53 |
| 28 | -40 | 1350 | -1.6 | -0.8 | 1710 | -990 |
| 29 | 285 | 1410 | 11.6 | 5.8 | 1315 | -1505 |
| 30 | -85 | 2745 | -1.8 | -0.9 | 4990 | -500 |
| 31 | 600 | 3900 | 8.9 | 4.4 | 5640 | -2160 |
| 32 | 1165 | 2240 | 31.3 | 15.6 | 2855 | -1625 |
| 33 | -225 | 5935 | -2.2 | -1.1 | 10020 | -1850 |
| 34 | 315 | 4015 | 4.5 | 2.2 | 7410 | -620 |
| 35 | -375 | 511 | -47.1 | -23.6 | 716 | -306 |
| 36 | 25 | 3235 | 0 | 0 | 4640 | -1830 |

# TABLE XVI
## Calculation of Principal Strains

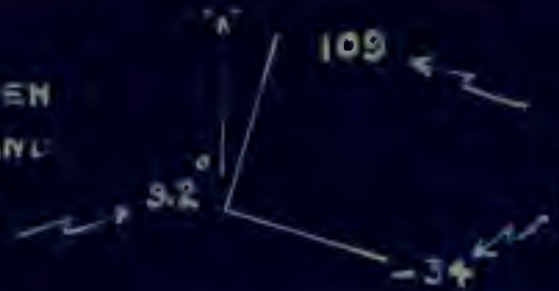
| Panel No. 2 Load 140,000 pounds | | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Gage No. | A Axis strain | B Axis strain | C Axis strain | $\frac{1}{2}$ (A+B) | A-D |
| 1 | 1160 | 630 | -30 | 565 | 595 |
| 2 | 1330 | 630 | -290 | 520 | 810 |
| 3 | 7770 | 4600 | -1230 | 3270 | 4500 |
| 4 | 5380 | 2840 | -1080 | 2150 | 3230 |
| 5 | 5250 | 1550 | -920 | 2165 | 3085 |
| 6 | 1540 | 520 | 60 | 800 | 740 |
| 7 | 1410 | 470 | -280 | 565 | 845 |
| 8 | 2340 | 380 | -1020 | 660 | 1680 |
| 9 | 6340 | 2770 | -620 | 2860 | 3480 |
| 10 | 7260 | 3320 | -180 | 3540 | 3720 |
| 11 | 4580 | 2190 | 1920 | 3250 | 1330 |
| 12 | off scale | 6000 | -1550 | | |
| 13 | 7490 | 3720 | -340 | 3575 | 3915 |
| 14 | 10800 | 3790 | -1890 | 4455 | 6345 |
| 15 | 7470 | 2560 | -1110 | 3180 | 4290 |
| 16 | 2950 | 660 | -1110 | 920 | 2030 |
| 17 | 1000 | 100 | -250 | 375 | 625 |
| 18 | 1830 | 490 | 140 | 985 | 845 |
| 19 | 10070 | 3780 | -1670 | 4200 | 5870 |
| 20 | 1270 | 860 | -160 | 555 | 715 |
| 21 | 1420 | 1070 | 230 | 825 | 595 |
| 22 | 1720 | 610 | -400 | 660 | 1060 |
| 23 | | | | | |
| 24 | 3760 | 2070 | -720 | 1520 | 2240 |
| 25 | 3350 | 180 | -1020 | 1165 | 2185 |
| 26 | 1490 | 180 | -250 | 620 | 870 |
| 27 | 1100 | 220 | 60 | 580 | 520 |
| 28 | 1710 | 320 | -990 | 360 | 1350 |
| 29 | 1290 | 190 | -1480 | -95 | 1385 |
| 30 | 4990 | 2160 | -500 | 2245 | 2745 |
| 31 | 5590 | 2340 | -2110 | 1740 | 3850 |
| 32 | 2530 | -550 | -1300 | 615 | 1915 |
| 33 | 10020 | 2860 | -1850 | 4085 | 5935 |
| 34 | 7410 | 3710 | -620 | 3395 | 4015 |
| 35 | 620 | -170 | -210 | 205 | 415 |
| 36 | 4640 | 1430 | -1830 | 1405 | 3235 |
| 37 | 10 | | | | |
| 38 | -240 | | | | |
| 39 | 1090 | | | | |
| 40 | 400 | | | | |
| 41 | -70 | | | | |
| 42 | 810 | | | | |

REW.
1-7-53

# TABLE XVII

RESULTS OF ROSETTE CALCULATIONS FOR PANEL ONE SHOWING DIRECTION AND MAGNITUDE OF PRINCIPAL STRAINS AS SEEN BY AN OBSERVER LOOKING AT AND THROUGH THE PANEL FROM THE UNSTIFFENED SIDE.

ANGLE BETWEEN STRAIN AXIS AND "A" AXIS OF PANEL.



PRINCIPAL STRAINS IN MICRO-INCHES PER INCH. TENSION IS POSITIVE.

| ROSETTE NUMBER | LOAD IN POUNDS<br>20,000 | 40,000 | 60,000 | 80,000 | 100,000 | 120,000 | 140,000 |
|---|---|---|---|---|---|---|---|
| 1 | 9.2<br>109<br>-34 | 11.4<br>262<br>-72 | 12.8<br>418<br>-138 | 14.1<br>737<br>-47 | 16.0<br>803<br>-273 | 15.0<br>1045<br>-335 | 14.2<br>1365<br>-365 |
| 2 | 7.8<br>281<br>-46 | 5.9<br>618<br>-118 | 6.4<br>924<br>-214 | 6.3<br>1238<br>-288 | 12.2<br>2485<br>-795 | 14.4<br>4810<br>-1310 | 10.2<br>7135<br>-1345 |
| 3 | 1.2<br>160<br>-70 | 0.1<br>330<br>-100 | 5.6<br>497<br>-217 | 2.2<br>690<br>-110 | 3.0<br>924<br>-134 | 2.2<br>1450<br>-170 | 3.3<br>2165<br>-335 |
| 4 | 4.0<br>373<br>-123 | 3.8<br>895<br>-305 | 0.9<br>1570<br>-620 | 2.4<br>2210<br>-760 | 2.6<br>3205<br>-1095 | 6.4<br>4750<br>-1330 | 3.6<br>6675<br>-1665 |
| 5 | 3.0<br>400<br>-90 | 1.6<br>1080<br>-220 | 0.4<br>2060<br>-620 | 2.8<br>3510<br>-1390 | 1.0<br>5680<br>-2100 | 0.4<br>6810<br>-2334 | 2.5<br>8770<br>-2770 |
| 6 | 2.2<br>440<br>-90 | 1.5<br>1080<br>-310 | 1.2<br>1840<br>-700 | 0.0<br>2680<br>-1100 | 2.2<br>4610<br>-2030 | 0.0<br>8150<br>-3530 | 2.4<br>9500<br>-3710 |
| 7 | 2.7<br>210<br>-110 | 3.0<br>392<br>-172 | 2.6<br>560<br>-230 | 2.0<br>750<br>-240 | 1.4<br>950<br>-290 | 1.8<br>1310<br>-460 | 1.3<br>2180<br>-960 |
| 8 | 2.6<br>90<br>-20 | 10.9<br>168<br>-48 | 15.4<br>275<br>-75 | 18.8<br>406<br>-136 | 20.8<br>551<br>-171 | 21.3<br>767<br>-242 | 19.4<br>1027<br>-297 |
| 9 | 5.9<br>223<br>-23 | 5.1<br>485<br>-75 | 4.5<br>705<br>-125 | 5.0<br>916<br>-176 | 7.4<br>1194<br>-254 | 13.4<br>1643<br>-223 | 16.0<br>2540<br>-180 |
| 10 | 12.0<br>217<br>-117 | 14.8<br>488<br>-238 | 12.2<br>760<br>-330 | 3.8<br>1570<br>-550 | 4.0<br>2605<br>-815 | 6.4<br>3645<br>-1195 | 0.7<br>6295<br>-1485 |
| 11 | 0.4<br>250<br>-10 | 0.0<br>575<br>-215 | 2.8<br>910<br>-330 | 4.8<br>1234<br>-434 | 6.7<br>1550<br>-530 | 8.4<br>1853<br>-613 | 4.4<br>3785<br>-675 |
| 12 | 0.0<br>80<br>-20 | 8.4<br>195<br>-45 | 10.6<br>314<br>-74 | 13.1<br>459<br>-109 | 14.8<br>644<br>-160 | 15.0<br>905<br>-335 | 13.9<br>1304<br>-324 |

R.E.W.
5-5-53

# TABLE XVII (CONT'D)

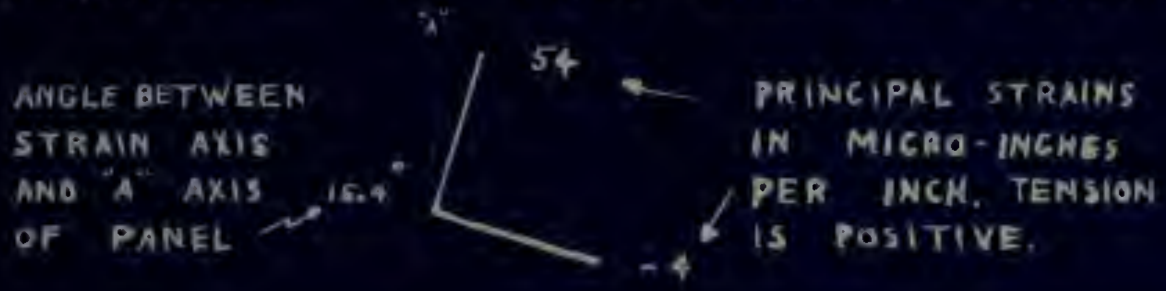
RESULTS OF ROSETTE CALCULATIONS FOR PANEL ONE SHOWING DIRECTION AND MAGNITUDE OF PRINCIPAL STRAINS AS SEEN BY AN OBSERVER LOOKING AT AND THROUGH THE PANEL FROM THE UNSTIFFENED SIDE.

| ROSETTE NUMBER | LOAD IN POUNDS | | | | | | |
|---|---|---|---|---|---|---|---|
| | 20,000 | 40,000 | 60,000 | 80,000 | 100,000 | 120,000 | 140,000 |
| 13 | 2.6 170 -50 | 2.8 301 -71 | 1.7 420 -90 | 1.0 545 -108 | 0.0 700 -120 | 1.9 930 -140 | 3.8 1238 -188 |
| 14 | 5.3 273 -53 | 5.8 548 -148 | 6.6 841 -231 | 6.6 1171 -331 | 12.6 2605 -895 | 12.4 4710 -1580 | 7.0 6305 -1555 |
| 15 | 2.2 400 -120 | 4.7 843 -263 | 6.0 1270 -400 | 6.2 1790 -530 | 8.7 2375 -1205 | 1.8 3160 -620 | 1.2 4510 -1180 |
| 16 | 8.6 258 -78 | 10.4 534 -194 | 10.7 798 -298 | 9.6 1019 -349 | 10.1 1396 -366 | 12.6 3425 -635 | 10.2 5915 -1025 |
| 17 | 0.0 85 -35 | 0.8 245 -69 | 3.0 406 -110 | 4.8 690 -154 | 5.9 797 -201 | 3.8 1072 -248 | 1.0 1585 -461 |
| 18 | 1.5 160 -30 | 3.6 271 -51 | 5.6 385 -75 | 3.9 514 -84 | 5.2 857 -93 | 7.0 915 -205 | 0.0 1230 -270 |
| 19 | 11.7 188 -38 | 13.2 362 -42 | 13.7 532 -32 | 7.6 714 -84 | 15.2 983 +77 | 0.8 1290 -230 | 9.2 1906 +194 |
| 20 | 4.8 203 -67 | 2.5 680 -196 | 0.6 1370 -594 | 1.8 2100 -904 | 5.2 3672 -1778 | 2.0 6920 -2956 | 2.2 8792 -3288 |
| 21 | 0.0 150 -130 | 5.1 760 -240 | 2.6 1500 -630 | 5.2 2825 -1415 | 3.2 4750 -2150 | 2.4 5820 -2260 | 1.5 7830 -2600 |
| 22 | 4.3 242 -92 | 2.9 654 -244 | 0.8 1230 -540 | 2.3 1740 -630 | 1.6 2060 -464 | 1.0 3750 -770 | 1.8 6175 -1265 |
| 23 | 0.0 150 -30 | 0.8 330 0 | 2.5 520 +60 | 10.5 803 -173 | 2.7 1074 +226 | 10.2 1510 -370 | 15.8 1173 +323 |
| 24 | 1.9 80 -60 | 6.5 173 -93 | 8.7 249 -119 | 8.0 319 -119 | 10.9 420 -120 | 11.5 622 -172 | 14.0 1019 -329 |
| 25 | 14.1 99 -34 | 7.0 194 -54 | 5.4 294 -84 | 4.4 423 -103 | 2.0 580 -130 | 2.0 820 -190 | 5.0 1281 -371 |
| 26 | 7.8 307 -67 | 4.0 665 -205 | 2.6 1040 -720 | 0.5 1350 -400 | 0.4 1610 -420 | 0.6 2170 -400 | 6.8 3750 -510 |
| 27 | 4.5 76 -20 | 3.7 156 -32 | 1.6 245 -41 | 3.8 367 -63 | 6.3 492 -76 | 5.6 692 -7 | 0.6 975 -159 |

RGW
5-1-53

# TABLE XVIII

RESULTS OF ROSETTE CALCULATIONS FOR PANEL TWO SHOWING DIRECTION AND MAGNITUDE OF PRINCIPAL STRAINS AS SEEN BY AN OBSERVER LOOKING AT AND THROUGH THE PANEL FROM THE UNSTIFFENED SIDE.


"A"
54
ANGLE BETWEEN STRAIN AXIS AND "A" AXIS OF PANEL
16.4°
-4
PRINCIPAL STRAINS IN MICRO-INCHES PER INCH. TENSION IS POSITIVE.

| ROSETTE NUMBER | LOAD IN POUNDS<br>20,000 | 40,000 | 60,000 | 80,000 | 100,000 | 120,000 | 140,000 |
|---|---|---|---|---|---|---|---|
| 1 | 54<br>15.4<br>-4 | 199<br>10.8<br>-19 | 347<br>7.2<br>-17 | 520<br>6.2<br>-40 | 703<br>3.5<br>-33 | 924<br>3.3<br>-34 | 1165<br>3.1<br>-35 |
| 2 | 135<br>15.0<br>-9 | 328<br>14.0<br>-118 | 527<br>10.8<br>-127 | 735<br>8.6<br>-195 | 910<br>8.0<br>-190 | 1143<br>5.7<br>-213 | 1335<br>3.9<br>-295 |
| 3 | 209<br>16.2<br>-41 | 716<br>3.0<br>-146 | 1130<br>1.1<br>-180 | 1870<br>1.8<br>-240 | 3540<br>3.9<br>-460 | 5486<br>3.8<br>-825 | 7960<br>8.2<br>-1420 |
| 4 | 314<br>3.4<br>-109 | 741<br>4.9<br>-201 | 1213<br>6.8<br>-293 | 1780<br>8.0<br>-400 | 2365<br>6.8<br>-475 | 3305<br>8.1<br>-615 | 5450<br>6.0<br>-1160 |
| 5 | 317<br>11.5<br>-67 | 633<br>9.2<br>-133 | 962<br>8.8<br>-222 | 1440<br>11.8<br>-300 | 2125<br>9.6<br>-655 | 3910<br>6.8<br>-1090 | 5305<br>5.6<br>-975 |
| 6 | 242<br>15.4<br>-52 | 473<br>11.1<br>-83 | 698<br>9.8<br>-108 | 900<br>10.8<br>-80 | 1101<br>12.2<br>-61 | 1390<br>11.8<br>-40 | 1590<br>10.3<br>+10 |
| 7 | 164<br>7.1<br>-34 | 326<br>6.8<br>-56 | 490<br>6.6<br>-80 | 655<br>7.0<br>-95 | 845<br>7.6<br>-115 | 1083<br>5.8<br>-173 | 1410<br>3.3<br>-285 |
| 8 | 143<br>5.1<br>-83 | 345<br>3.7<br>-195 | 560<br>2.3<br>-310 | 850<br>2.4<br>-440 | 1250<br>2.6<br>-620 | 1745<br>3.7<br>-815 | 2360<br>4.8<br>-1040 |
| 9 | 320<br>0.0<br>-60 | 700<br>0.7<br>-120 | 1100<br>0.0<br>-200 | 2070<br>0.8<br>-300 | 3550<br>2.9<br>-410 | 5160<br>0.3<br>-520 | 6340<br>0.8<br>-620 |
| 10 | 500<br>0.0<br>-60 | 1050<br>0.8<br>-120 | 1650<br>0.8<br>-200 | 2880<br>1.6<br>-270 | 4550<br>0.5<br>-260 | 6090<br>1.5<br>-210 | 7260<br>1.7<br>-180 |
| 11 | 340<br>0.4<br>-110 | 1050<br>2.0<br>-240 | 1560<br>2.4<br>-380 | 2085<br>3.1<br>-615 | 2465<br>4.1<br>-955 | 3055<br>6.2<br>-1365 | 4950<br>18.3<br>+1550 |
| 12 | 730<br>1.0<br>-100 | 1440<br>1.6<br>-190 | 2430<br>0.8<br>-260 | 4410<br>0.3<br>-320 | 6370<br>0.6<br>-430 | 10460<br>0.8<br>-750 | OFF SCALE |

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# TABLE XVIII (CONT'D)

RESULTS OF ROSETTE CALCULATIONS FOR PANEL TWO SHOWING DIRECTION AND MAGNITUDE OF PRINCIPAL STRAINS AS SEEN BY AN OBSERVER LOOKING AT AND THROUGH THE PANEL FROM THE UNSTIFFENED SIDE.

| ROSETTE NUMBER | LOAD IN POUNDS | | | | | | |
|---|---|---|---|---|---|---|---|
| | 20,000 | 40,000 | 60,000 | 80,000 | 100,000 | 140,000 | 160,000 |
| 13 | 581<br>4.2 -107 | 600<br>36.6 -610 | 2075<br>4.3 -265 | 3225<br>4.3 -335 | 4350<br>2.8 -70 | 5490<br>3.2 -390 | 7490<br>1.0 -340 |
| 14 | 420<br>2.3 -80 | 850<br>2.5 -180 | 1115<br>4.2 -585 | 1695<br>3.4 -405 | 3980<br>2.0 -1740 | 7990<br>2.4 -1440 | 10 801<br>3.0 -1891 |
| 15 | 254<br>5.0 -84 | 586<br>3.8 -194 | 1358<br>4.6 -368 | 3325<br>8.2 -635 | 4735<br>6.6 -805 | 6085<br>4.4 -965 | 7510<br>4.1 -1160 |
| 16 | 153<br>4.7 -93 | 360<br>2.5 -210 | 678<br>3.4 -318 | 1174<br>3.4 -454 | 1730<br>3.4 -630 | 2360<br>3.6 -850 | 2970<br>3.6 -1130 |
| 17 | 92<br>18.8 -32 | 189<br>15.8 -69 | 312<br>13.2 -92 | 456<br>11.6 -126 | 593<br>12.1 -163 | 786<br>12.2 -226 | 1058<br>11.9 -308 |
| 18 | 192<br>18.6 -22 | 434<br>15.4 -34 | 716<br>13.7 -46 | 1000<br>13.3 -50 | 1280<br>14.4 -50 | 1592<br>15.2 -32 | 1965<br>15.2 +5 |
| 19 | 476<br>4.8 -66 | 1415<br>4.0 -105 | 2760<br>3.2 -240 | 4530<br>0.4 -500 | 6550<br>1.8 -750 | 8210<br>1.8 -1180 | 10 070<br>2.0 -1670 |
| 20 | 32<br>52.0 -52 | 119<br>31.5 -29 | 287<br>18.8 -57 | 506<br>15.5 -96 | 718<br>14.1 -108 | 987<br>13.0 -141 | 1330<br>11.6 -220 |
| 21 | 177<br>20.4 -37 | 390<br>16.9 -60 | 597<br>14.9 -67 | 807<br>12.9 -67 | 995<br>12.0 -35 | 1214<br>11.2 +66 | 1468<br>11.2 +182 |
| 22 | 179<br>20.6 -49 | 355<br>18.0 -105 | 542<br>14.0 -142 | 728<br>11.2 -168 | 875<br>9.0 -155 | 1065<br>3.4 -195 | 1720<br>1.3 -400 |
| 24 | 350<br>0.7 -56 | 739<br>4.3 -129 | 1102<br>6.3 -182 | 1443<br>9.4 -243 | 1735<br>12.6 -275 | 2225<br>13.2 -375 | 3820<br>6.9 -780 |
| 25 | 286<br>12.1 -78 | 528<br>11.4 -168 | 749<br>10.6 -279 | 971<br>11.3 -461 | 1320<br>12.1 -750 | 2235<br>13.0 -985 | 3565<br>12.2 -1235 |
| 26 | 201<br>30.6 -21 | 404<br>14.4 -114 | 568<br>12.6 -158 | 687<br>11.2 -177 | 795<br>10.9 -175 | 1020<br>11.8 -210 | 1585<br>13.4 -355 |
| 27 | 235<br>31.3 -5 | 384<br>12.6 -84 | 560<br>11.6 -100 | 705<br>13.0 -95 | 860<br>15.9 -90 | 1038<br>17.2 -58 | 1213<br>17.4 -53 |

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# TABLE XVIII (CONT'D)

RESULTS OF ROSETTE CALCULATIONS FOR PANEL TWO SHOWING DIRECTION AND MAGNITUDE OF PRINCIPAL STRAINS AS SEEN BY AN OBSERVER LOOKING AT AND THROUGH THE PANEL FROM THE UNSTIFFENED SIDE.

| ROSETTE NUMBER | LOAD IN POUNDS | | | | | | |
|---|---|---|---|---|---|---|---|
| | 20,000 | 40,000 | 60,000 | 80,000 | 100,000 | 120,000 | 140,000 |
| 28 | 6<br>33.8<br>-46 | 78<br>9.9<br>-158 | 138<br>7.7<br>-238 | 185<br>12.0<br>-335 | 343<br>11.1<br>-533 | 740<br>4.8<br>-750 | 1710<br>0.8<br>-990 |
| 29 | -142<br>22.5<br>-158 | -171<br>14.8<br>-319 | -216<br>6.4<br>-484 | -357<br>4.2<br>-693 | -308<br>8.0<br>-1002 | 180<br>8.4<br>-1280 | 1315<br>5.8<br>-1505 |
| 30 | 33<br>16.7<br>-113 | 132<br>8.6<br>-232 | 295<br>8.0<br>-325 | 493<br>8.5<br>-363 | 898<br>7.1<br>-369 | 2040<br>1.9<br>-420 | 4990<br>0.9<br>-500 |
| 31 | -160<br>0.0<br>-180 | -232<br>15.4<br>-348 | -311<br>11.9<br>-509 | -303<br>5.6<br>-767 | 180<br>2.3<br>-1060 | 1665<br>4.4<br>-1635 | 5640<br>4.4<br>-2160 |
| 32 | -107<br>33.5<br>-183 | -164<br>30.1<br>-346 | -177<br>30.2<br>-663 | -49<br>20.5<br>-1001 | 318<br>26.2<br>-1398 | 1540<br>35.5<br>-1095 | 2855<br>15.6<br>-1625 |
| 33 | 50<br>2.2<br>-80 | 224<br>3.7<br>-244 | 540<br>3.6<br>-420 | 1230<br>1.1<br>-600 | 3420<br>0.0<br>-930 | 7220<br>0.4<br>-1470 | 10820<br>1.1<br>-1850 |
| 34 | 172<br>4.0<br>-42 | 380<br>1.2<br>-100 | 1086<br>5.2<br>-226 | 2960<br>6.1<br>-360 | 4585<br>6.6<br>-435 | 6095<br>4.8<br>-505 | 7410<br>2.2<br>-620 |
| 35 | 96<br>19.5<br>-46 | 196<br>12.8<br>-106 | 320<br>14.3<br>-140 | 435<br>13.7<br>-175 | 540<br>15.0<br>-220 | 644<br>17.6<br>-274 | 716<br>23.6<br>-386 |
| 36 | 202<br>14.8<br>-122 | 383<br>15.4<br>-203 | 744<br>10.2<br>-464 | 1440<br>1.2<br>-610 | 2420<br>0.0<br>-1030 | 3410<br>0.7<br>-1410 | 4640<br>0.0<br>-1830 |
| 37 | -10 | -70 | -130 | -160 | -150 | -90 | +10 |
| 38 | 110 | 30 | -100 | -240 | -290 | -300 | -240 |
| 39 | 430 | 530 | 530 | 520 | 640 | 840 | 1090 |
| 40 | 230 | 210 | 140 | 90 | 110 | 210 | 400 |
| 41 42 | 110 200 | 50 280 | -50 260 | -170 240 | -190 340 | -160 510 | -70 810 |

## APPENDIX D

## References

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